

UNCLASSIFIED

AD NUMBER

AD483183

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

FROM:

Distribution authorized to DoD only;
Administrative/Operational Use; MAR 1966. Other
requests shall be referred to U.S. Army
Materiel Command, Projects Managers Office,
Washington, DC.

AUTHORITY

USAAVSCOM ltr 12 Nov 1973

THIS PAGE IS UNCLASSIFIED

483183



AD _____

1. RTD&E PROJECT NO. 1X141815D193
2. USATECOM PROJECT NO. 4-3-1170-08
3. USAAVNTA PROJECT NO. 65-10

STABILITY AND CONTROL AND PERFORMANCE TEST
(PHASE D)
OF THE CV-7A TRANSPORT AIRPLANE

FINAL REPORT

JOHN T. BLAHA
PROJECT ENGINEER

NORMAN A. MATTMULLER
MAJOR, TC
AND
DONALD R. WILSON
PROJECTS PILOTS

MARCH 1966

U.S. ARMY AVIATION TEST ACTIVITY
EDWARDS AFB, CALIFORNIA

DDC AVAILABILITY NOTICE

U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through Hq, U. S. Army Materiel Command (USAMC), CV-7A Project Manager's Office, Washington, D. C.

REPRODUCTION LIMITATIONS

Reproduction of this document in whole or in part is prohibited except with permission of Hq, USAMC, CV-7A Project Manager's Office, Washington, D. C. DDC is authorized to produce the document for United States Government purposes.

DISPOSITION INSTRUCTIONS

Destroy this report when no longer needed. Do not return it to the originator.

DISCLAIMER

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

TRADE NAMES

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial purposes of advertisement.

This document may be further distributed by any holder only with specific prior approval of CV-7A Project Manager, Hq, U. S. Army Materiel Command, Washington, D. C.

1. RDT&E PROJECT NO. 1X141815D193
2. (USATECOM PROJECT NO. 4-3-1170-08)
3. (USAAVNTA PROJECT NO. 65-10)

STABILITY AND CONTROL AND PERFORMANCE TEST
(PHASE D)
OF THE CV-7A TRANSPORT AIRPLANE

FINAL REPORT

JOHN T. BLAHA
PROJECT ENGINEER

NORMAN A. MATTMULLER
MAJOR, TC
AND
DONALD R. WILSON
PROJECT PILOTS

MARCH 1966

U. S. ARMY AVIATION TEST ACTIVITY

This document may be further distributed by any holder only
with specific prior approval of CV-7A Project Manager, Hq,
U. S. Army Materiel Command, Washington, D. C.

ABSTRACT

An engineering flight evaluation of the CV-7A (Buffalo) Transport Airplane, Serial Number 63-13687, was conducted by the U.S. Army Aviation Test Activity (USAAVNTA). The objective was to conduct those engineering flight tests required to complete the necessary engineering flight test program for an Army transport airplane. The STOL characteristics were emphasized during this evaluation.

The USAAVNTA was responsible for planning, executing, and reporting the test. Sixty-five productive hours were flown between 19 August 1965 and 24 November 1965, at Edwards Air Force Base, California, and remote test sites at Lake Tahoe, California, and Leadville, Colorado.

The CV-7A met all the essential performance requirements of the Qualitative Materiel Requirement and performance guarantees of the Model Specification that could be evaluated as a result of the limited performance tests conducted. The CV-7A presented a considerable performance improvement over the CV-2B in terms of payload while maintaining a similar STOL capability.

The stability and control characteristics of the CV-7A were considerably improved over those of the CV-2B although the STOL landing handling qualities were marginal. These should be improved to take full advantage of the performance capabilities of the airplane.

STOL takeoff distances were found to be shorter and STOL landing distances were slightly longer than those presented in the Operator's Manual. A considerable increase in STOL takeoff performance was achieved by loading the airplane to an aft center of gravity.

Correction of two shortcomings revealed in this evaluation would result in a STOL airplane of improved capability.

The CV-7A demonstrated excellent availability in this program. Except for a foreflap failure of an unresolved origin, it was flyable every day. This availability rate, however, could not have been achieved if engine start reliability depended on the auxiliary power unit (APU), which proved unreliable and unpredictable.

FOREWORD

1. AUTHORITY

a. Letter, AMSTE-BG, Hq, U.S. Army Test and Evaluation Command (USATECOM), 2 April 1965, subject: "Test Directive, USATECOM Project-Task Number 4-3-1170-08, Abbreviated Phase D (STOL) Test, CV-7A Transport Airplane."

b. Letter, AMSTE-BG, Hq, USATECOM, 30 April 1965, subject: "Amendment to Test Directive, USATECOM Project-Task Number 4-3-1170-08."

2. REFERENCES

a. Model Specification, "U.S. Prototype Tactical Transport Airplane (STOL) CV-7A," U.S. Army Contract DA 44-177-AMC-15(T), Issue 3, The de Havilland Aircraft of Canada Ltd., 15 March 1964.

b. Model Specification E1086, "Engine, Aircraft, Turbo-prop, T-64-GE-10," General Electric Company, 1 October 1964.

c. "Letter Report on Limited Preliminary Engineering Flight Evaluation for CV-7A Tactical Transport Airplane," U.S. Army Aviation Test Activity (USAAVNTA) 31 July 1964.

d. "Letter Report on Preliminary Engineering Flight Evaluation of the CV-7A Tactical Transport," USAAVNTA, 12 October 1964.

e. "Plan of Test for STOL Takeoff and Landing Engineering Flight Tests of the CV-7A Airplane," USAAVNTA, March 1965.

f. "Plan of Test for Stability and Control and Performance Testing (Phase D) for the CV-7A Transport Airplane," USAAVNTA, May 1965.

g. Proposed Qualitative Materiel Requirement (QMR) for a Tactical Transport Aircraft, 4-5 ton (STOL) (U), 24 June 1965.

h. Military Specification MIL-F-8785 (ASG), "Flying Qualities of Piloted Airplanes," 1 September 1954.

i. Preliminary Operator's Manual, U. S. Army CV-7A Aircraft, Department of the Army, 15 April 1965, Revised 20 June 1965.

j. Civil Aeronautics Manual Part 4b, Federal Aviation Agency, September 1962.

k. "Final Report of Service Test of the CV-7A Airplane," USATECOM Project Number 4-3-1170-02, U.S. Army Aviation Test Board, 5 November 1965.

l. "Final Report of Performance Tests of the CV-2B Airplane," USATECOM Project Number 4-4-1141-01, USAAVNTA, June 1965.

m. Report TR 6273, "Flight Test Engineering Manual," U.S. Air Force Flight Test Center, May 1951.

n. Report TN-R-12, "Standardization of Takeoff Performance Measurements for Airplanes," U.S. AFFTC, 1948.

o. Report TN-59-21, "AFFTC Stability and Control Techniques," U.S. AFFTC, May 1959.

TABLE OF CONTENTS

	Page
ABSTRACT	v
FOREWARD	vii
SECTION 1. GENERAL	1
1.1 Objectives	1
1.2 Responsibilities	1
1.3 Description of Materiel	1
1.4 Background	3
1.5 Findings	4
1.6 Conclusions	4
1.7 Recommendations	4
SECTION 2. DETAILS OF TEST.....	7
2.0 Introduction	7
2.1 Short Field Takeoff Performance and Handling Qualities	8
2.2 Short Field Landing Performance and Handling Qualities	16
2.3 Stability and Control	22
2.4 Performance	38
SECTION 3. APPENDICES	51
I Test Data	51
II Nomenclature and Data Analysis Method	111
III Test Instrumentation	116
IV General Aircraft Information	118
SECTION 4. DISTRIBUTION LIST.....	123

SECTION 1 - GENERAL

1.1 OBJECTIVES

The objective of these tests was to conduct those engineering flight tests required to complete the necessary engineering flight test program for an Army transport airplane.

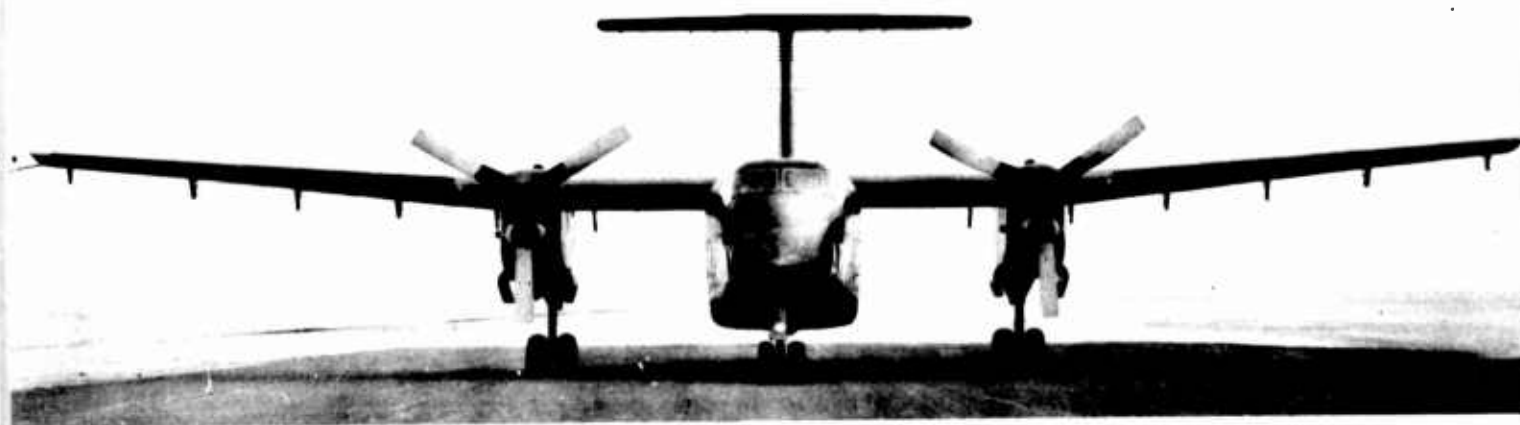
1.2 RESPONSIBILITIES

The U.S. Army Aviation Test Activity (USAAVNTA) was designated as Executive Test Agency for this flight test evaluation and was responsible for test planning, test execution, and test reporting.

1.3 DESCRIPTION OF MATERIEL

The CV-7A "Buffalo" is an all-metal, high-wing, twin-engine, tricycle-gear airplane and is a growth version of the CV-28 "Caribou." The airplane is designated as a medium troop/cargo short takeoff and landing (STOL) transport with a 3-5 ton payload capability. The airplane is capable of instrument day and night operations from hastily prepared and/or selected unprepared surfaces. Power is supplied by two T64-GE-10 turbo-prop engines equipped with Hamilton Standard 63E60-13 constant speed, variable and reversible pitch propellers. The tricycle landing gear, hydraulically actuated, is fully retractable. Electrically-operated cargo and ramp doors in the rear of the airplane are used for loading and unloading troops and cargo. Normal flight crew consists of a pilot, copilot, and crew chief. Seating for 34 fully equipped troops is provided in the main cabin with provisions for 7 additional forward-facing seats along the cabin longitudinal centerline. Fuel is contained in four main tanks with a total fuel capacity of 13,560 pounds (2086 U.S. gallons). The maximum takeoff gross weight of the airplane is 38,000 pounds. (See Reference a for additional details.)

One CV-7A airplane, Serial Number 65-13687, was used for this evaluation. The basic configuration of the airplane was standard except for the instrumentation used during the test phase. Externally, a 5-foot swivel-head airspeed boom was mounted on the right leading-edge wing tip. The internal con-



figuration was standard except for special cockpit instrumentation and a worktable, seat, photo panel, and 50-channel oscillograph installed in the main cabin for use by the Flight Test Engineer. Ballast located in the main cabin consisting of 25-pound lead bags, was stored at various aircraft stations to obtain the required weight and center of gravity (C.G.) for each test. See Section 3, Appendix II, for a listing and photographs of installed test instrumentation.

Longitudinal and lateral control are obtained through mechanically actuated elevators and ailerons. Directional control is obtained with a two-segment rudder, which employs an irreversible, hydraulically-powered system. The lateral and directional control trim system uses a mechanical linkage. Wing mounted spoilers are used to augment lateral control in flight and operate concurrently after landing to reduce lift during roll-out. Full-span, trailing-edge, hydraulically actuated, double-slotted flaps are used as high-lift and drag-producing devices. Aileron droop is employed in the flap extension cycle. On the ground, directional control is obtained with a hydraulically powered nosewheel steering system.

1.4 BACKGROUND

USAAVNTA personnel have been monitoring and participating in the contractor flight test program. Two preliminary evaluations were conducted by this Activity in May and October 1964 (References c and d). At a meeting held in the CV-7A Project Manager's office on 12 January 1965, USAAVNTA was requested to prepare a test plan for a high-altitude takeoff and landing performance evaluation.

USAAVNTA Plan of Test for STOL Takeoff and Landing Engineering Flight Tests of the CV-7A Airplane, March 1965, was prepared to meet that requirement (Reference e). A Test Directive to USAAVNTA from USATECOM, 30 April 1965, requested a test plan delineating all those engineering tests required to complete the engineering flight test program for an Army STOL transport airplane (Foreword 1.b). Plan of Test to fulfill this objective was prepared by USAAVNTA (Reference f).

1.5 FINDINGS

See Section 2 for a full discussion of test findings.

1.6 CONCLUSIONS

a. The CV-7A airplane meets all of the essential performance requirements of the OMR (Reference g) and performance guarantees of the Model Specification (Reference a) that could be evaluated as a result of the limited performance tests conducted during this evaluation.

b. The CV-7A represents a considerable performance improvement over the CV-2B in terms of payload while maintaining a similar STOL capability.

c. Pilot qualitative comments indicate that the CV-7A has considerably better stability and control characteristics than the CV-2B although the CV-7A STOL landing handling qualities are marginal and should be improved to take full advantage of the performance capabilities of the airplane.

d. The correction of the shortcomings listed in Paragraph 1.7 will result in a STOL airplane of improved capability.

1.7 RECOMMENDATIONS

a. Correction of the following shortcomings in the CV-7A will result in a STOL airplane of improved capability:

- (1) Marginal flying qualities in the STOL landing configuration (Reference Paragraph 2.2.4.2).
- (2) Failure of the torquemeter to arm the auto-feathering circuit under ambient conditions where 650 foot-pounds of torque cannot be attained at takeoff power (Reference Paragraph 2.1.4.1).

b. Studies should be initiated by the airplane contractor to:

- (1) Investigate the feasibility of installing anti-skid brakes on the CV-7A or an alternate method of preventing excessive tire wear during heavy braking (Reference Paragraph 2.1.2.4).
- (2) Increase the zero fuel gross weight from 34,000 pounds to 36,500 pounds (Reference Paragraph 2.3.1.4).
- (3) Improve the flying qualities during a STOL landing (Reference Paragraph 2.2.4.2).
- (4) Determine the feasibility of reducing the stick force per "g" in cruise flight to the limits specified by MIL-F-8785 (Reference h).
- (5) Determine the feasibility of reducing the rudder breakout forces (Reference Paragraph 2.3.10.4).
- (6) Determine the feasibility of demonstrating stalls at takeoff power in the STOL takeoff configuration (Reference Paragraph 2.3.9.4).

c. The Operator's Manual (Reference i) should be amended to include:

- (1) The results of the STOL takeoff and landing performance presented in this report (Reference Paragraph 2.1.4.1 and 2.1.4.2).
- (2) Appropriate notation describing the STOL takeoff performance advantages obtained in loading to an aft C.G. (Reference Paragraph 2.1.4.1).

- (3) A tabulated or graphical presentation of gross weight versus recommended yoke-pull airspeed when conducting STOL takeoffs (Reference Paragraph 2.1.4.1).
- (4) Appropriate notation describing the near ideal ambient conditions under which the handbook STOL landing data was obtained and the effects of the non-ideal conditions on landing distance (Reference Paragraph 2.2.4.1).
- (5) Appropriate notation describing consequences of premature rotation during a STOL takeoff (Reference Paragraph 2.1.4.1).
- (6) Appropriate notation describing the adverse attitude and subsequent recovery problems associated with stalls in the STOL configurations at an aft C.G. (Reference Paragraph 2.3.9.4).
- (7) Appropriate warnings concerning the relationship of the airspeeds required for STOL performance to the stall speeds and minimum single engine control speeds (Reference Paragraph 2.1.4.1).

d. When the CV-7A is procured for general service use a production airplane with calibrated low-time engines should be made available to a Government flight test facility for the purpose of conducting handbook performance flight tests (Reference Paragraph 2.4).

SECTION 2 - DETAILS OF TEST

2.0 INTRODUCTION

This report presents the results of an engineering flight test evaluation of the CV-7A conducted by the USAAVNTA. Sixty-five productive hours were flown during the period of 19 August through 24 November 1965, at Edwards Air Force Base, California, and remote test sites located at Lake Tahoe, California (elevation 7000 feet), and Leadville, Colorado (elevation 10,000 feet).

The test program was terminated prior to completion because of field deployment of the test airplane. The major portions of the test not completed were in the performance area. The crosswind landing tests and sea-level and unprepared surface takeoff and landing performance tests were also not accomplished.

Limited uninstrumented landings were made in crosswinds up to 15 to 20 knots. A steady wind of this velocity did not appear to present any problems but a gusty wind magnified the stability and control shortcomings during a STOL landing. This will be expanded upon in the stability and control section.

The following nomenclature is used throughout the report in reference to the various airplane configurations tested:

Configuration	Symbol	Trim Airspeed	Landing		
			Flaps	Gear	Power
Takeoff STOL	TO _{STOL}	As recommended	30°	Up	TO
Landing STOL	L _{STOL}	As recommended	40°	Down	Flt Idle
Power Approach STOL	PA _{STOL}	As recommended	40°	Down	PLF
Cruise	CR	165 KCAS	0°	Up	PLF
Climb	CL	As recommended	0°	Up	NRP

Tests were accomplished whenever possible in the priority list of the Test Plan (Reference f).

All tests were conducted in non-turbulent atmospheric conditions. The takeoffs and landings were conducted in less than 5 knots of wind.

The CV-7A demonstrated excellent availability during the tests. Except for a foreflap failure of an as yet unresolved origin, the CV-7A was flyable every day. This availability rate could not have been achieved if the reliability of the engine starts depended on the auxiliary power unit (APU). The APU performance during this evaluation was unreliable and unpredictable.

The requirements of MIL-F-8785 were used as a guide for the stability and control portion of this evaluation.

2.1 SHORT FIELD TAKEOFF PERFORMANCE AND HANDLING QUALITIES

2.1.1 OBJECTIVE

The objective of these tests was to define the short field takeoff performance of the CV-7A as a function of gross weight and airfield altitude. A further objective was to develop the flight techniques required to obtain consistent maximum short field takeoff performance and to evaluate the effect that the CV-7A handling qualities have on attaining consistent maximum performance.

2.1.2 METHOD

Short field takeoff tests were conducted at airfields having average pressure altitudes of 2250 feet, 6000 feet, and 9500 feet. Density altitudes at the 9500-foot site averaged over 11,000 feet during the evaluation. Test data corrected to standard day is presented in Section 3, Appendix I, at the altitude which minimizes the magnitude of the corrections from test to standard day. Gross weights were varied from 27,000 pounds to 36,500 pounds with the



STOL TAKEOFF FROM HIGH ALTITUDE TEST SITE

center of gravity position varied from the forward limit to the aft limit. Takeoffs were made at consecutively lower rotation airspeeds until the maximum performance takeoff airspeed, consistent with safety, was achieved. All takeoffs were conducted in winds of 5 knots or less.

The piloting technique to achieve maximum takeoff performance which evolved during the tests was as follows:

The pilot fully depressed the brake pedals, set power to the takeoff setting with his right hand and kept his left hand on the nosewheel steering wheel. The copilot held the control wheel near neutral. After brake release, the pilot maintained runway alignment with nosewheel steering to 40-50 knots and then put both hands on the control wheel, shaking it to indicate that he was taking control. The copilot monitored engine torque, turbine inlet temperatures, oil pressure and fuel flow during the ground roll and initial climbout. At the pre-selected rotation airspeed, the control wheel was pulled aft an amount sufficient to cause a brisk rotation rate of 9 to 11 degrees per second (or full aft if that rate could not be attained). Pilot attention was transferred outside the airplane as rotation was begun. The primary pilot cue during rotation was normal acceleration. When adequate normal acceleration was sensed, rotation was continued, the gear handle moved to "up" and pilot attention returned to the airspeed indicator. Any trend observed at that time was stopped and the resulting steady airspeed flown through 50 feet. If a significant amount of normal acceleration was not sensed at rotation, rotation was stopped and/or reversed and gear retraction delayed until it was clear that the airplane would stay airborne. As a normal procedure the copilot moved the flap handle toward "up" when the pilot moved the gear handle. The rate of flap retraction was well matched to the time required to reach 50 feet

and the subsequent acceleration of the airplane at light weights (less than 34,000 pounds). At heavier weights at altitudes above 5000 feet, however, a delay in moving the flap handle until attaining 60 knots IAS was advisable to prevent settling. This delay in flap retraction caused a negligible decrease in takeoff performance.

All longitudinal trim settings within the "takeoff range" were satisfactory. Control of the airspeed through 50 feet, however, was improved by trimming at the nose-up end of the range for forward C.G. and vice versa. Neutral rudder trim was used throughout and was satisfactory even though right rudder was required from rotation to 50 feet. Neutral aileron trim was used and was satisfactory.

2.1.3 RESULTS

The results of the short field takeoff tests are presented graphically in Figures 3 through 10, and are summarized in Figures 1 and 2, Section 3, Appendix I.

2.1.4 ANALYSIS

2.1.4.1 Performance

The measured STOL takeoff distances were shorter than the distances published in the Operator's Manual (Reference 1). The Manual should be amended to reflect the measured STOL takeoff performance results obtained during this evaluation. The following table compares the evaluation STOL takeoff results with those presented in the Operator's Manual:

Altitude ft	Gross Weight lb	Evaluation Results		Handbook Performance	
		Ground Roll ft	Distance to 50 ft ft	Ground Roll ft	Distance to 50 ft ft
Sea Level	27,500	340	540	400	700
	34,000	580	910	600	925
	36,500	690	1030	720	1075
6000	27,500	470	800	520	850
	34,000	760	1180	925	1350
	36,500	875	1335	1150	1620
10,000	27,500	625	1030	700	1100
	34,000	970	1480	1250	1750
	36,500	1160	1860	1475	2150

The contractor data upon which the Operator's Manual STOL takeoff performance chart is based was obtained at sea level. This data was also obtained at relatively heavy gross weights (34,000 to 38,000 pounds). The table presented shows good agreement between evaluation and Manual results at sea level at gross weights of 34,000 and 36,500 pounds. The difference between the Operator's Manual presented STOL takeoff performance and that measured during the evaluation increases as airfield altitude increases.

Maximum performance was obtained using 30 degrees of flap at gross weights up to 34,000 pounds and 25 degrees of flap at heavier gross weights. The following table depicts the recommended yoke-pull airspeeds for several gross weights as well as the "target" 50-foot airspeeds for forward and aft C.G. limits. The yoke-pull airspeeds presented are valid for all C.G. positions and altitudes at the specified gross weight:

Gross Weight lb	Recommended Yoke-pull Airspeed kt	Indicated Airspeed at 50 feet - kt	
		Fwd C.G.	Aft C.G.
27,500	50	62	59
32,000	55	66	63
34,000	60	68	65
36,500	65	70.5	67.5

The yoke-pull airspeeds and indicated airspeeds at 50 feet show good agreement with those presented in the Operator's Manual. In order to obtain consistent maximum performance an effort should be made to rotate at the airspeed listed for the particular gross weight. The Operator's Manual generalizes the rotation airspeed by stating below 34,000 pounds rotation should be between 50 and 60 knots and above 34,000 pounds between 60 and 70 knots. A tabulated or graphical presentation of gross weight versus recommended yoke-pull airspeed should be included in the Operator's Manual. Rotation at yoke-pull airspeeds below those indicated may cause over-rotation and aircraft "settling" resulting in excessively long takeoff distances. The over-rotation situation will be particularly critical at an aft C.G. loading and low-power-to-weight ratio condition (i.e., high altitude, hot day, heavy gross weight).

A warning should be inserted in the Operator's Manual regarding the consequences of premature rotation and the conditions under which it will most likely occur. The Operator's Manual presents a limited discussion on the relationships between the minimum single engine control airspeeds and the airspeeds necessary to obtain STOL performance. This section should be amplified to

include options available to a pilot following an engine failure during a STOL takeoff under various combinations of gross weight and ambient conditions.

The Operator's Manual presents STOL takeoff performance estimates at only a forward C.G. loading. A considerable increase in takeoff performance can be realized by loading the airplane at an aft C.G. The following table depicting performance from a runway located at a standard-day altitude of 6000 feet illustrated the magnitude of this difference:

Forward C.G. (26.5% MAC)			Aft C.G. (41.5% MAC)	
Gross Weight lb	Ground Roll ft	Distance to 50 ft ft	Ground Roll ft	Distance to 50 ft ft
27,500	470	800	390	660
32,000	665	1055	565	890
36,500	880	1340	860	1270

This table shows that a 17.5 percent decrease in takeoff distance can be achieved by loading to an aft C.G. as compared with loading to a forward C.G. at 27,500 pounds gross weight. As gross weight increases and recommended rotation airspeed increases the percentage change in takeoff performance becomes smaller. This is understandable because at the higher rotation airspeeds necessary at the heavier gross weights, the elevator becomes more effective. A note should be inserted in the Operator's Manual informing the operator of the STOL takeoff performance advantages to be gained by loading the airplane to an aft C.G.

The torquemeters on the CV-7A are an integral part of the auto-feathering system. The auto-feathering system is armed automatically when an engine torque of 650 foot-pounds is reached. Under certain ambient conditions of high altitude and warm temperatures a torque of 650 foot-pounds cannot be achieved without exceeding the turbine inlet temperature limit. This leaves the operator without the protection of auto-feathering on takeoff under these conditions. This situation should be corrected as soon as possible and is considered a safety-of-flight condition.

No STOL takeoff data was obtained at sea level which is the altitude at which the guarantee is based (Paragraph 3.1.2.1.1, Reference a). The guaranteed distance at 34,000 pounds over a 50-foot obstacle is 1000 feet \pm 50 feet on a firm dry sod field. The evaluation extrapolated data indicates that this guarantee is met. The sea level STOL takeoff distance at a forward C.G. on dry concrete was determined to be 905 feet. The Operator's Manual presents an estimate that an additional 50 feet would be required when conducting a STOL takeoff under guarantee conditions on dry sod as opposed to dry concrete. This would correct the evaluation-measured distance to 955 feet, which would meet the guarantee.

The CV-7A could take off and clear a 50-foot obstacle on a sea level standard day from a hard surfaced runway in 1000 feet at a gross weight of 36,000 pounds, which corresponds to a useful load of 11,800 pounds. The CV-2B, under the same conditions could take off at a gross weight of 27,000 pounds, which corresponds to a useful load of 6200 pounds. Both of these figures are based on a forward C.G. loading. Considerable increase in performance could be obtained by loading both to an aft C.G.

2.1.4.2 STOL Takeoff Handling Qualities

Attaining consistent maximum STOL takeoff performance does not require any unusual pilot skills.

The landing gear retraction rate was noticeably more rapid than on the CV-2B. All gear were normally up and doors were closing at 50 feet. The direction of movement of the landing gear handle was logical and convenient; however, pilots normally flying both CV-2B's and CV-7A's may find it confusing because of its opposite movement.

Over-rotating will not occur as long as yoke-pull airspeeds below those recommended in this report are not attempted and the previously described technique is used.

At gross weights above 34,000 pounds, stall warning (wheel shaker) was experienced during rotation and infrequently during the climbout. The warning obviously had no meaning since it did not alert the pilot to any danger or require any action from him. It will be necessary to ask transitioning pilots to ignore the shaker stall warning and continue rotating despite its presence. This is not a desirable condition as stall warnings should always be meaningful.

2.2 SHORT FIELD LANDING PERFORMANCE AND HANDLING QUALITIES

2.2.1 OBJECTIVE

The objective of these tests was to define the short field landing performance of the CV-7A as a function of gross weight and airfield altitude. A further objective was to define the flight techniques necessary to attain maximum landing performance and to evaluate the effect that the CV-7A handling qualities in the STOL flight regime have on attaining consistent maximum short field landing performance.

2.2.2 METHOD

Short field landing tests were conducted at airfields having average pressure altitudes of 2250 feet, 6000 feet, and 9500 feet. Gross weights were varied from 27,000 to 36,500 pounds with C.G. position varying from the forward limit to the aft limit. Approaches were made

at consecutively lower airspeeds until the minimum airspeed consistent with safety was attained. All landing tests were performed in winds of 5 knots or less.

The technique which was developed to attain maximum performance was as follows:

The airplane was aligned with the runway at a height of 700 to 800 feet at an indicated airspeed of 85 to 90 knots. Landing gear was in the down position and the flaps set at 30 degrees. A shallow descent was initiated and full flaps (40 degrees) and approach propeller mode were selected. The airplane was then decelerated to the desired approach airspeed or that airspeed plus the airspeed loss expected from wind shear. The proper landing sight picture was intercepted at 300 to 400 feet at which time the throttles were retarded to the idle stops. Both hands were placed on the wheel with the throttles left on the idle stops. The airplane attitude was adjusted to hold the desired approach airspeed. This attitude, once determined, was maintained until flare height was reached. This height was judged by eye and increased with field elevation. When the flare height was reached aft wheel was applied to cause a continuous increase in pitch rate. The intent of each landing was to touch down at a sink rate of 4 to 5 feet per second with the nosewheel 2 to 3 feet off the runway. Full reverse throttle was applied after touchdown as soon as the right hand could be moved from the wheel to the throttles. Wheel braking was begun when the airplane felt solid on the runway and was discontinuous. This braking technique was not considered maximum but a practical maximum considering the chance of skidding and blowing a tire with heavier braking. Consideration should be given to installing anti-skid brakes on the CV-7A to enable the airplane to safely and consistently obtain the landing performance of

which it is inherently capable. Braking was continued until the airplane came to a stop. The throttles were brought out of reverse just before the airplane came to a stop.

2.2.3 RESULTS

The results of the short field landing tests are presented graphically in Figures 12 through 15 and are summarized in Figure 11, Appendix I.

2.2.4 ANALYSIS

2.2.4.1 Performance

In most cases the measured STOL landing distances of the CV-7A were longer than those published in the Operator's Manual. The Operator's Manual should be amended to reflect the measured landing performance results obtained during this evaluation. The following table illustrates the difference in measured landing performance obtained during the evaluation and that published in the Operator's Manual:

Standard Day Altitude ft	Gross Weight lb	Evaluation Results		Handbook Performance	
		Ground Roll ft	Distance over 50 ft	Ground Roll ft	Distance over 50 ft
6000	34,000	667	1070	525	1010
6000	36,500	700	1118	575	1075
6000	27,000	445	860	405	850

This table reveals that a sizeable difference exists between ground phase distances of the evaluation results and those published in the Operator's Manual. This difference

can be explained in several ways. First, the Manual landing data was obtained during limited tests conducted at sea level and extrapolated to the various gross weights and ambient conditions presented in the Manual. Second, the landing performance during the evaluation could have been improved by reversing the propellers just prior to touchdown. This technique was not considered feasible for operational use for the CV-7A aircraft and, therefore, was not used. Third, moderate, not maximum, braking was used during the evaluation. The braking technique used was practical for operational use without risking blown tires. During the evaluation, several tires were "scrubbed" severely enough so that they had to be replaced. This condition was most severe during lightweight landings.

The STOL performance data presented in this report was obtained during nearly ideal ambient conditions and thereby represents the maximum performance of which the CV-7A is capable. In actual operation pilots will ordinarily not have the advantages of the near ideal ambient conditions and controlled test advantages that were available during this test program. In addition, the CV-7A has several stability and control shortcomings in the STOL landing configuration which will reduce the achievable performance under adverse ambient conditions. These will be elaborated upon in the handling qualities portion of this section and in the stability and control section (Paragraph 2.3). A statement should be included in the Operator's Manual describing the conditions under which the Manual data was gathered and the probable effects of non-ideal conditions on landing distance.

No landing data was obtained at sea level which is the altitude for the contractor's guarantee (Paragraph 3.1.2.1.4, Reference a). The guaranteed distance at 34,000 pounds over a 50-foot obstacle is 1000 feet \pm 50 feet on a firm dry sod field. Extrapolated data from this evaluation indicates that this guarantee was met. The sea level landing distance on dry concrete at 34,000 pounds was 970 feet. The Manual presents an estimate that an additional 75 feet of ground roll would be required when landing under the guarantee conditions on

dry sand, opposed to dry concrete. This would correct the evaluation measured distance to 1045 feet, which meets the guarantee.

The final approach airspeed recommended schedule as presented in the Operator's Manual closely matches the recommended airspeeds determined during this evaluation. The following table indicates the recommended airspeeds at all airport altitudes and C.G. locations for their respective gross weights:

Gross Weight lb	Indicated Airspeed kt
27,000	60
32,000	65.5
34,000	67.5
36,500	70

The safe flight indicator provided an excellent indication of the optimum airspeed that should be flown on final approach but was too sluggish in response to wind shear and gusts to be used as a primary flight aid during the approach. The procedure recommended for consistent maximum performance is to determine the optimum approach airspeed by centering the safe flight indicator, then continuing the approach using the airspeed indicator as the primary flight instrument.

The CV-7A could land over a 50-foot obstacle on a sea level standard day on a hard surfaced runway in 1000 feet at a gross weight of 36,500 pounds, which corresponds to a useful load of 12,300 pounds. The CV-2B under the same conditions could land at a gross weight of 28,500

pounds, which corresponds to a useful load of 7700 pounds.

2.2.4.2 STOL Landing Handling Qualities

The handling qualities during a STOL landing are the major shortcomings of the CV-7A airplane. Qualitatively, the STOL landing handling qualities are considerably improved over those of the CV-2B; however, they leave a lot to be desired. The stability and control shortcomings, which contribute to the marginal handling qualities in the STOL landing configuration and which will be expanded upon in the stability and control discussion (Paragraph 2.3) are:

- a. Weak or neutral dihedral effect
- b. An excessive time lag in roll response after an aileron input
- c. High rudder pedal breakout forces
- d. Low lateral-directional damping

The combination of these factors contributed to a pilot induced aileron movement during turbulent condition landings. A turbulent air final approach, which resulted in a hard landing, is depicted in Figure 16, Appendix I. The result of these large aileron, hence spoiler, motions was an apparent sizeable increase in rate of descent. The energy available to stop a normal rate of descent at the recommended approach airspeed was insufficient to arrest satisfactorily the increased rate of descent and a hard landing resulted. A study should be initiated by the contractor to improve the handling qualities during STOL landings. If this cannot be satisfactorily accomplished, alternate recommended STOL landing techniques should be investigated (i.e., power approaches, less flaps, etc.) with their subsequent loss in performance.

Even in smooth air, attaining consistent maximum STOL landing performance required a high degree of pilot proficiency. The crux of a good STOL landing is selecting

the proper height to commence the flare. This height increases with density altitude. The difference in time of commencing the flare properly or improperly and either floating several hundred feet or making a hard touchdown is on the order of one-half a second.

2.3 STABILITY AND CONTROL

The tests conducted during the stability and control portion of the evaluation concentrated on the STOL flight regime and other areas of flight peculiar to the military mission and not completely evaluated during the course of the Canadian Department of Transport (DOT) Certification under Civil Aeronautics Manual (CAM), Part 4(b), (Reference j).

The requirements of MIL-F-8785, "Flying Qualities of Piloted Airplanes," (Reference h) were used as a guide for the stability and control portion of the evaluation.

The requirement of the QMR (Reference g) for stability and control is: "for good stability and control characteristics over the operational speed range. Control in the low speed range shall be consistent with the requirements for slow speed operation, short takeoff and landing performance, and aerial delivery." The CV-7A demonstrates good flying qualities during the airline-type operation for which it was certified; however, the STOL landing flying qualities are only marginally acceptable. The CV-7A does, however, represent an improvement in handling qualities over those of the CV-2B. The low lateral control power and random "snaking" in yaw during STOL landings which were two of the major shortcomings of the CV-2B have been improved in the CV-7A although the latter still has an objectional lag in roll response.

2.3.1 STATIC LONGITUDINAL STABILITY

2.3.1.1 Objective

The objective of these tests was to confirm that the stick-fixed and stick-free neutral points for the CV-7A were

aft of the most aft permissible C.G. location for the STOL flight regime.

2.3.1.2 Method

The airplane was stabilized at the recommended STOL landing and power approach airspeeds. Without re-trimming or changing power settings, the airplane was slowed approximately 15 knots. The speed was then increased to approximately 15 knots above the original trim airspeed then slowed back down to the trim airspeed. Stabilized data points were taken approximately every 3 or 4 knots during the above sequence.

Tests were conducted in the STOL landing, STOL power approach, and climb configurations at an average density altitude of 7500 feet. Gross weights were varied from approximately 38,000 to 30,000 pounds with the C.G. varying between the forward and aft limit.

2.3.1.3 Results

The results of the static longitudinal stability tests are presented graphically in Figures 17 through 22, Appendix I.

2.3.1.4 Analysis

The static longitudinal stability was positive and acceptable for all flight regimes tested. The longitudinal control forces and position gradients were smooth throughout the speed ranges of interest with no reversals or discontinuities.

The following table summarizes the neutral points obtained during the evaluation:

Configuration	Stick-Fixed % MAC Neutral Point	Stick-Free % MAC Neutral Point	Aft C.G. Limit
STOL Landing	59	52.5	41.5
STOL Power Approach	53	50.5	41.5
Climb	50	44.5	41.5

The static longitudinal stability characteristics were found to be a function primarily of C.G. position and configuration. The secondary influence of gross weight does not significantly affect the static longitudinal stability.

2.3.2 MANEUVERING STABILITY

2.3.2.1 Objective

The objective of these tests was to evaluate the maneuvering flight characteristics of the CV-7A. Emphasis was placed on determining that the maneuvering stability, stick-fixed and stick-free, was positive and the elevator force per "g" was within the limits specified by MIL-F-8785 (Reference h).

2.3.2.2 Method

The maneuvering flight characteristics were evaluated by means of the steady-turn method. The airplane was stabilized in turns at various incremental load factors while a constant airspeed was maintained. Power and trim settings were maintained at the level flight trim point for the test airspeed. Altitude was allowed to vary during the test. Data was recorded when the airspeed and load factor were stabilized.

Tests were conducted at the forward and aft limit C.G.'s in the STOL takeoff, STOL landing, STOL power approach, and cruise configuration.

2.3.2.3 Results

The results of the maneuvering stability tests are presented graphically in Figures 23 through 26, Appendix I.

2.3.2.4 Analysis

The maneuvering stability of the CV-7A was positive in all configurations and airplane loadings tested with the maneuvering neutral points located well aft of the corresponding static longitudinal neutral points.

Longitudinal control force gradients were acceptable in all of the STOL configurations tested. The gradients were positive and essentially linear up to the stall limited load factor obtainable. The control force gradients in the cruise configuration were undesirably high throughout the C.G. range at the 30,000-pound gross weight where the design limit load factor is 3.0 "g's". The magnitude of this gradient (80 pounds/g at the forward C.G.) will make it difficult for a pilot to take advantage of the structural maneuvering capability of the airplane. It is recommended that a study be conducted by the contractor to determine the feasibility of decreasing the control force per "g" without introducing "flutter" or other adverse handling qualities. Above 34,000 pounds gross weight, the airplane maneuvering design limit is 2.5 "g" and the gradients are acceptable but tend to be high.

The spring tab elevator control system on the CV-7A masked the stick-free maneuvering stability characteristics at low elevator force inputs (i.e., below 40 pounds). For all practical purposes the apparent stick-free maneuvering stability at these low inputs is independent of C.G. location. Within the limits of the maneuvering tests conducted, this characteristic is not undesirable.

In the cruise configuration, above approximately 40 pounds of elevator force, a decrease in the stick force per "g" gradient occurred at the aft C.G. This decrease apparently occurred as the elevator control was transferred from the spring tab to the elevator itself. This transfer in control was smooth and not discernible to the pilot. The departure of linearity at the stick force per "g" curve in the cruise configuration at an aft C.G. was well within the 50 percent departure in linearity from the average gradient specified by MIL-F-8785 and was not objectionable.

No tendency for the CV-7A to exhibit "g" overshooting was noted in any of the configurations tested (i.e., following sudden pull-ups from trimmed flight, the ratio of the maximum elevator control force to maximum change in normal acceleration was never less than the ratio of force to acceleration change obtained in steady accelerations under the same conditions).

2.3.3 LONGITUDINAL TRIM CHANGES

2.3.3.1 Objective

The objective of these tests was to evaluate the longitudinal trim changes of the CV-7A associated with changes in configuration.

2.3.3.2 Method

The airplane was stabilized in each of the trim configurations listed in the table presented in Paragraph 2.3.3.3 of this section. The specified configuration change was then accomplished and the specified parameter was maintained constant. The resulting maximum longitudinal force obtained without retrimming was recorded.

Tests were conducted at a gross weight of 32,000 pounds and a forward C.G. (26.6 percent MAC) at an average density altitude of 7500 feet.

2.3.3.3 Results

The results of the longitudinal trim change test are summarized in the following table:

Initial Trim Condition					Parameter To Be Held Constant	Maximum Longitudinal pound-force
Speed	Gear	Flaps	Power	Configuration Change		
Limit Gear Speed	Up	Up	PLF	Gear Down	Altitude	5 aft (pull)
Limit Flap Speed	Down	Up	PLF	Flaps Down	Altitude	12 fwd (push) (after 5 sec)
STOL Power Approach	Down	Down	PLF	Idle Power	Speed	7.5 fwd (push)
STOL Power Approach	Down	Down	PLF	Takeoff Power	Altitude	3 aft (pull)
STOL Takeoff	Down	Down	T0	Gear Up	Rate of Climb	3 aft (pull)
STOL Takeoff	Up	Down	T0	Flaps Up	Rate of Climb	5 fwd (push)
V _{NRP}	Up	Up	NRP	Idle Power	Altitude	7 aft (pull) (after 5 sec)
100 KCAS	Up	Up	PLF	Lower Ramp to Level	Altitude	5 aft (pull)

2.3.3.4 Analysis

The tabulated values for longitudinal trim change show that all trim changes are less than the 20-pound limit of MIL-F-8785 and are acceptable. The low magnitude of the trim changes is considered excellent for an airplane of this class with an unboosted longitudinal control.

2.3.4 STATIC LATERAL-DIRECTIONAL STABILITY

2.3.4.1 Objective

The objective of these tests was to determine the static directional stability characteristics and effective dihedral.

2.3.4.2 Method

The CV-7A was stabilized at the desired flight condition, configuration, and airspeed. Steady non-turning sideslips were then introduced in both directions from trim. The airspeed was maintained at the trim value throughout the sideslip series.

Static lateral-directional stability tests were conducted at an average density altitude of 7500 feet, at gross weights varying from 38,000 to 30,000 pounds and C.G. positions varying from 26.5 to 41.5 percent MAC (the forward and aft C.G. limits).

2.3.4.3 Results

The results of the static lateral-directional stability tests are presented graphically in Figures 27 through 30, Appendix I.

2.3.4.4 Analysis

The CV-7A exhibited positive static directional stability in all configurations tested. The pedal deflection-versus-sideslip angle was essentially linear to the practical limit sideslip angles tested.

A nose-down longitudinal trim change occurred in sideslips in the climb, STO! landing and power approach configurations. This trim change occurred in both left and right sideslips and required approximately a 10-pound

elevator pull force to maintain airspeed at the maximum sideslip angles tested. This trim change was not objectionable and was within the 15-pound maximum trim change specified in MIL-F-8785.

The dihedral effect, both stick-fixed and stick-free, was positive in the clean configurations tested (i.e., climb and cruise). In the power approach configuration, neutral control position dihedral was observed. The rudder-aileron tab interconnect introduced an artificial stick-free dihedral effect. In the STOL landing configuration the initial stick-fixed dihedral effect was positive; however, above approximately 12 to 15 degrees of sideslip, the dihedral effect became neutral. Sideslip angles of 12 to 15 degrees are not uncommon during a turbulent air STOL landing approach. This lack of a stabilizing lateral moment following a disturbance in roll and the resulting sideslip is one of the factors contributing to the marginal flying qualities during a turbulent air STOL approach. As a result of these tests it is recommended that further studies be conducted to correct the weak dihedral effect present in the STOL landing and power approach configurations. If the weak dihedral effect cannot be corrected, tests should be conducted with the rudder-aileron tab interconnect disconnected to determine if a better trade-off in flying qualities is obtained to better accomplish, more effectively, the military mission.

The sideforce characteristics of the CV-7A were satisfactory. The variation of bank angle versus sideslip angle was in the correct direction through the zero sideslip trim conditions tested.

2.3.5 COORDINATED AILERON ROLLS

2.3.5.1 Objective

The objective of these tests was to evaluate the rolling characteristics of the CV-7A following an abrupt aileron input.

2.3.5.2 Method

The airplane was stabilized in a bank in one direction and abruptly rolled to the corresponding bank angle in the opposite direction. The roll was coordinated with the rudder. Various size inputs to both the left and right were utilized. The roll rate, maximum aileron force, amount of rudder required for coordination and time to achieve initial roll rate, and maximum roll rate after the control input were recorded.

Tests were conducted in the STOL landing, power approach and cruise configurations.

2.3.5.3 Results

The results of the coordinated roll tests are summarized in Figures 31 through 33, Appendix I. Time histories of aileron rolls in the landing configuration are presented in Figures 34 and 35.

2.3.5.4 Analysis

The aileron roll characteristics in the STOL landing configuration were the major shortcomings of the CV-7A. A time lag of 0.3 to 0.5 seconds after aileron control input was experienced before the airplane developed a roll rate. This is illustrated in Figures 34 and 35, Appendix I. Once a roll rate started, the roll acceleration was high. On numerous occasions, while performing STOL landings under turbulent conditions, the aircraft demonstrated a tendency to easily establish a pilot-induced lateral oscillation. An example of such a condition is shown in Figure 16. The result of this rapid control reversal was to open the spoilers rapidly and alternately. This resulted in higher-than-desirable sink rates during rotation prior to landing. It is recommended that a study be instituted by the contractor to determine the cause of this lateral control response lag and the feasibility of remedying it.

The CV-7A met the requirements of MIL-F-8785 for rolling performance in all configurations tested. Even in the STOL landing configuration, despite the objectionable lag in developing a rate, the rapid roll acceleration once a rate developed, was sufficient to meet the specification requirements.

The aileron forces necessary to achieve the above rolling performance were within the specification limits and are acceptable. The rudder required to cancel the large adverse yaw tendency discussed in Paragraph 2.3.6 was relatively high; however, the rudder required was essentially linear with size of aileron input and thus made coordination of rolls acceptable.

2.3.6 PEDAL-FIXED AILERON ROLLS

2.3.6.1 Objective

The objective of these tests was to evaluate the adverse yaw characteristics of the CV-7A following an abrupt aileron input.

2.3.6.2 Method

The airplane was stabilized in a bank in one direction and abruptly rolled to the corresponding bank angle in the opposite direction. The rudder pedals were held fixed during this maneuver. Various size aileron inputs to both the left and right were utilized. The maximum sideslip angle resulting from this maneuver was recorded.

Tests were conducted in both the STOL landing configuration and the STOL power approach configurations.

2.3.6.3 Results

The results of the pedal-fixed aileron rolls are presented graphically in Figures 36 and 37, Appendix I.

2.3.6.4 Analysis

The CV-7A in the STOL configurations exhibited adverse yaw characteristics that were slightly greater than the maximum allowable specified in MIL-F-8785. The specification limit adverse yaw is 15 degrees; whereas the CV-7A exhibited adverse yaw angles as high as 20 degrees. The specification further requires that the change in adverse yaw with aileron deflection should be essentially linear. The CV-7A exhibited a rapid increase in adverse yaw at small aileron inputs; whereas the adverse yaw became more nearly constant as the size of the aileron input was increased.

The adverse yaw characteristics of the CV-7A, although not objectionable in themselves, contributed to the overall marginal flying characteristics of the CV-7A during STOL landings in turbulent air.

2.3.7 DYNAMIC STABILITY

2.3.7.1 Objective

The objective of these tests was to insure that the airplane oscillations following a gust or other disturbances from trimmed flight were satisfactorily damped about all axes.

2.3.7.2 Method

The dynamic stability of the CV-7A was investigated by artificially disturbing the airplane about each axis in a manner that would permit evaluation of each of its fundamental modes of motion. The following table illustrates the tests utilized during the evaluation to investigate each mode of motion:

Axis	Mode of Motion	Method of Excitation
Pitch	Short Period	1/2 to 1 "g" longitudinal control pulses
Pitch	Phugoid	Release controls after slowing aircraft approximately 15 knots from trim
Roll Yaw	Dutch Roll	Release from steady non-turning sideslips
Roll Yaw	Spiral Divergence	Disturb aircraft in a steady bank with an asymmetric power surge. Note time to double bank angle

The dynamic stability characteristics of the CV-7A were investigated at a heavy gross weight and forward C.G. at a density altitude of 7500 feet, and at a light gross weight and aft C.G. at altitudes of 7500 and 25,000 feet. Configurations investigated included STOL landing and power approach, climb, and cruise.

2.3.7.3 Results

Selected results of the dynamic stability tests are presented in the form of time histories in Figures 39 through 41, Appendix I.

2.3.7.4 Analysis

The longitudinal short-period mode of motion was essentially deadbeat for all configurations tested. A slight decrease in damping was observed in the cruise configuration at 25,000 feet as compared with 7500 feet; however, the motion was still very heavily damped and satisfactory. The phugoid mode of motion was satisfactorily damped in all configurations tested.

The "dutch roll" mode of motion was satisfactorily damped in the cruise and climb configuration at all altitudes. The damping of this mode in the STOL landing and power approach configurations was only marginally acceptable. Following a yaw axis disturbance in the STOL configurations a "dutch roll" with a relatively high yaw to roll ratio was induced. This mode was unusually easy to excite in this airplane because of the gust responsiveness of the CV-7A in yaw. This is another stability and control factor contributing to the marginal flying qualities during a turbulent air STOL landing.

The spiral stability mode of motion met the requirements of MIL-F-8785, in all cases except in a STOL power approach configuration. Following a disturbance in bank in the STOL power approach configuration the bank angle was doubled in approximately 8 seconds. The specification requires that this angle shall not double in this configuration in less than 20 seconds. The specification intent with the 20-second time limit to double the bank angle is to insure satisfactory flying qualities during an instrument approach when attention may be diverted to reading maps, tuning radios, etc. If no instrument approaches in the STOL power approach configuration (i.e., full flaps) are planned with this airplane, this deviation from the specification requirement will not be important.

2.3.8 STOL MINIMUM CONTROL AIRSPEEDS

2.3.8.1 Objective

The objective of this test was to evaluate the response of the CV-7A following an engine failure during a STOL takeoff.

2.3.8.2 Method

The minimum control airspeed was evaluated by shutting down one engine at a safe airspeed and altitude, applying takeoff power to the other engine and slowing the airplane until non-turning flight could no longer

be attained. This procedure was then repeated with the other engine and the minimum control airspeed with the critical engine noted. A simulated engine failure of the critical engine on an actual STOL takeoff at $V_{mc} + 5$ knots and at V_{mc} were conducted and evaluated. The test was conducted at an intermediate gross weight of 32,000 pounds and an aft limit C.G. loading.

2.3.8.3 Results

A time history of a critical engine failure during a STOL takeoff is presented in Figure 42, Appendix I.

2.3.8.4 Analysis

Failure of the left engine was determined to be more critical than failure of the right engine during a STOL takeoff. Full right rudder was required at an indicated airspeed of 68 knots. Minimum control indicated airspeed as defined by ability to hold non-turning flight with a maximum bank angle of 5 degrees was 65 knots. Because of test conditions, the maximum takeoff horsepower attainable without exceeding the turbine inlet temperature limit was approximately 2300 shaft horsepower/engine.

A failure of the left engine at an indicated airspeed of 65 knots during a STOL takeoff required no exceptional pilot skill to maintain control of the airplane and continue the climbout.

2.3.9 STOL STALL CHARACTERISTICS

2.3.9.1 Objective

The objective of the stall tests was to insure that the CV-7A exhibited satisfactory stall characteristics in the STOL flight regime.

2.3.9.2 Method

Tests were conducted in the STOL landing and take-off configurations at gross weights ranging from 29,000 to 38,000 pounds at both forward and aft limit C.G. position.

All stalls were initiated from a trim airspeed of between 70 and 80 knots indicated airspeed. The airspeed was decreased at a rate of from 1/2 to 1 knot per second to minimize dynamic effects. Takeoff configuration stalls were limited to 1000 shaft horsepower per engine. This was the maximum demonstrated by the contractor.

2.3.9.3 Results

Typical results of the stall tests are presented in the form of time histories in Figures 43 and 44, Appendix I.

2.3.9.4 Analysis

A complete aerodynamic stall could not be achieved at a forward C.G. loading in any of the configurations tested because of limited elevator control power available. Minimum flying speed at this loading was characterized by a high sink rate with all controls remaining effective.

Sufficient elevator control was available at an aft C.G. to produce an aerodynamic stall. Increasing right rudder was required as the stall was approached. The pedal force gradient was not high enough, however, to act as a stall warning. Approximately 1 knot above the stall, the airplane rolled left despite the application of full-right lateral control. The stall in all configurations was characterized by a nose-down pitching moment. The combination of the left roll attitude coupled with the nose-down stall pitching moment produced uncomfortable attitudes for recovery. In the STOL takeoff configuration at an aft C.G. with 1000 shaft horsepower/engine, heavy buffett was experienced in the aft section of the cabin prior to the stall. Light and gaps could be distinguished around the cargo door during this maneuver.

Stall warning consisting of the stick shaker, nose-high attitude, and left rolling tendency produced adequate stall warning.

Conventional stall recoveries did not produce any secondary stall tendencies. The elevator was effective

during all stall recoveries but its effect noticeably deteriorated as the C.G. moved aft. Stalls in all configurations at an aft C.G. presented a recovery problem. The initial left wing dropping coupled with the nose-down stall that occurred almost immediately resulted in attitudes which made it difficult to recover without exceeding both the flap limit airspeed and load factor. This condition was critical at a high weight in the STOL landing configuration. Under test conditions at 31,000 pounds, an aft limit C.G. loading, and the STOL landing configuration, approximately 900 feet of altitude was required for recovery with the airspeed reaching the flap limit redline despite a 2.1 "g" normal acceleration. Appropriate notation should be placed in the Operator's Manual warning of the attitudes, airspeeds, and load factors that result from an aft C.G. stall.

The ships airspeed indicator, occasionally gave erroneous readings during lightweight, aft C.G. takeoff configuration stalls. Indicated airspeeds of 20 to 30 knots were observed at stall under these conditions.

The desirability of having the contractor demonstrate STOL takeoff and STOL "go-around" stalls at takeoff power still exists although the potential structural problems that might occur during the recovery from such a stall are recognized. The contractor should conduct a study to determine the feasibility of demonstrating these stalls, then discuss the results of this study with representatives of an appropriate Government flight test facility. As a minimum, the contractor should be required to demonstrate flight to the verge of stall under these conditions.

2.3.10 CONTROL BREAKOUT FORCES

2.3.10.1 Objective

The objective of these tests was to insure that control breakout forces were within the limits of MIL-F-8785.

2.3.10.2 Method

The rudder breakout force was determined statically on the ground by noting at what rudder force the rudder began to deflect. The elevator and aileron breakout forces were determined in flight in conjunction with the static longitudinal and static lateral-directional tests by recording the control force required to attain a corresponding control surface deflection.

2.3.10.3 Results

A plot of rudder deflection versus rudder force is presented in Figure 38, Appendix I.

2.3.10.4 Analysis

The rudder pedal breakout force was approximately 17 pounds to both the left and the right. This exceeded the 14-pound maximum specified by MIL-F-8785. The effect of a high rudder breakout force was to make precise rudder control difficult. The excessive adverse yaw present in the CV-7A in the STOL landing and power approach configurations (See Paragraph 2.3.6.4) and the large rudder inputs necessary for coordinated aileron rolls required precise rudder control to accurately coordinate aileron inputs. The high rudder breakout force was considered one of the factors that contributed to the marginal flying qualities during STOL landings.

The lateral and longitudinal control breakout forces were between 1 and 4 pounds and were within the limits of MIL-F-8785 and acceptable.

2.4 PERFORMANCE

The level flight and climb performance power required data presented in this report is based on engine torquemeter indicated power corrected for speed decenter

gear losses. The estimated gear losses were obtained from the engine manufacturer as was the Model Specification engine power available and fuel flow (Reference b). Propeller efficiencies were computed from charts furnished by the propeller manufacturer.

The only torque calibration available for the test engines were the original test cell calibrations conducted by the engine manufacturer well over 100 hours before this evaluation. Comparison of referred engine parameters, plus expected installation losses with the uninstalled engine characteristics as well as comparison of test data with airframe contractor level flight performance data, indicated that the torquemeters gave fairly reliable indications of power. The performance results presented in this report are, therefore, considered to give a reliable estimate of the performance capabilities of the CV-7A. Should the CV-7A be procured for service use, a production airplane with calibrated low time engines should be made available to a Government flight test facility for handbook performance flight tests.

The limited time available for the performance tests necessitated cancelling many of the planned tests that would have completely defined compliance with the Model Specification (Reference a) and the QMR (Reference g). The tests were chosen in a priority order that would give the maximum amount of information in the minimum calendar time available.

The airplane Model Specification (Reference a) bases most of the performance guarantees on a useful load associated with the maximum gross weight at which STOL capability was predicted (34,000 pounds) at the time the specification was prepared. STOL operation is defined as takeoff and landing capability, on a sea level standard day from a dry concrete runway, over a 50-foot obstacle, of less than 1000 feet. Evaluation results indicate that the CV-7A has STOL capability up to approximately 36,000 pounds. Reference k indicates that the CV-7A exceeds the empty weight guarantee by 666 pounds. All range, climb, and maximum airspeed guarantees, therefore, were evaluated at 34,666 pounds gross weight, at which weight STOL capability still existed.

2.4.1 LEVEL FLIGHT

2.4.1.1 Objective

The objective of the level flight tests was to define the level flight performance of the CV-7A in terms of range capabilities, optimum cruising airspeeds, and maximum achievable airspeeds.

2.4.1.2 Method

The level flight performance was evaluated by conducting tests to determine the power required in level flight. The tests were flown using the "pressure altitude" technique which amounts to flying a given test at a constant weight divided by pressure ratio, i.e., increasing altitude on successive test points as fuel is consumed. All data was recorded when the airplane was completely stabilized in non-turbulent air.

Tests were conducted at an average gross weight of 37,500 pounds at density altitudes of 5000, 10,000, 15,000, and 25,000 feet. One test was conducted at a gross weight of 28,700 pounds at an altitude of 5000 feet. Fuel flow values were obtained from the engine Model Specification (Reference b) and no conservatism is included in the results presented.

2.4.1.3 Results

The results of the level flight tests are presented graphically in Figures 45 through 50, Appendix I.

2.4.1.4 Analysis

The specific ranges determined during this evaluation agreed reasonably well with those presented in the Operator's Manual (Reference i). The cruise airspeeds determined during the evaluation to attain maximum range were consistently lower than those presented in the Operator's Manual by between 10 and 15 knots true airspeed (KTAS).

The following table summarizes the standard day cruise performance obtained during this evaluation:

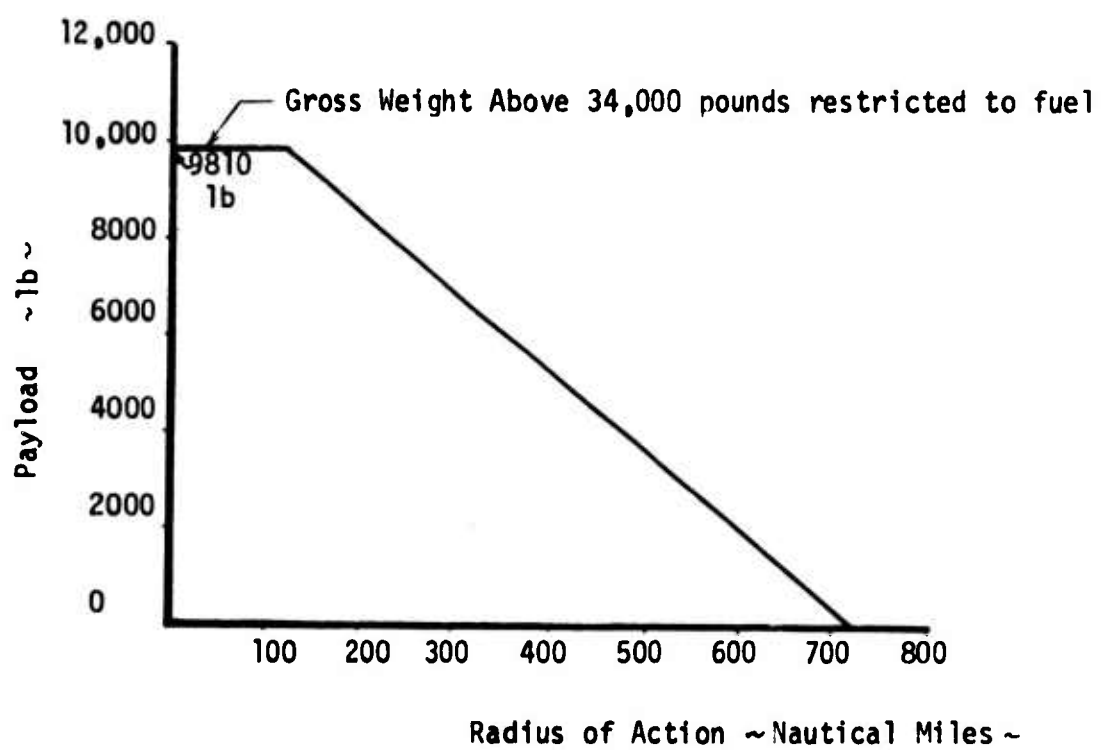
Altitude ft	Gross Weight lb	Recommended Cruise Airspeed KTAS	Nautical Air Miles miles (NAMPP) lb-fuel
5000	28,700	157	0.1432
5000	37,400	164	0.1335
10,000	37,450	167	0.1492
15,000	37,450	168	0.1669
25,000	37,550	186	0.2010

On a standard day at altitudes below 15,000 feet and gross weights as high as 38,000 pounds, the placard limit airspeed will be reached at a lower power setting than military rated power (MRP). The maximum airspeeds obtained during the evaluation at MRP and normal rated power (NRP) settings agreed within 1 to 2 percent of those published in the Operator's Manual. The following table summarizes the standard day maximum airspeeds of the CV-7A determined during the evaluation:

Altitude ft	Gross Weight lb	Maximum Airspeed KTAS	Factor Limiting Maximum Airspeed
5000	28,700	235	Placard
5000	37,400	235	Placard
10,000	37,450	240	Placard
15,000	37,450	246	Placard
25,000	37,550	242	MRP

The following graph shows the payload versus radius of action performance of the CV-7A as calculated from test data. The mission assumes a gross weight at which STOL operation is possible. From Figure 1, Appendix I, this gross weight will be approximately 36,000 pounds for the CV-7A. The following conditions were used when calculating the mission:

- a. Cruise at 5000 feet on a zero wind standard day
- b. Cruise at optimum long range airspeed
- c. Allowance of fuel equivalent to 5 minutes at NRP for each takeoff
- d. Final landing with a fuel reserve of 10 percent of initial fuel
- e. No refueling at mission midpoint
- f. Full payload outbound, one-half payload inbound
- g. Fuel consumption increased by 5 percent over engine manufacturer's specification values
- h. Operating weight with a 3-man crew = 24,190 lbs
- i. Engine start gross weight = 36,000 lbs



The preceding graph shows the penalty in terms of payload that results from the 34,000 pound zero-fuel gross weight restriction. A break in the mission radius curve and a constant maximum payload is reached at a mission radius of approximately 125 nautical miles. The difference between the extrapolated curve and this constant maximum payload is equal to the payload which cannot be carried because of this restriction. During a 50 to 100 nautical mile mission this amounts to over 1000 pounds of payload.

The CV-7A can carry 9810 pounds payload when flying the above mission over a 100-nautical mile radius. The CV-2B can carry a payload of approximately 5375 pounds while flying the same mission. (The calculations for the CV-2B were made from data contained in Reference e with an operating weight of 20,800 pounds and a maximum STOL gross weight of 27,000 pounds.)

No level flight performance tests were flown at sea level, the altitude on which the level flight performance guarantees of the Model Specification (Reference a) and requirements of the QMR (Reference g) are based. The breakdown in the following paragraph therefore, is based on extrapolated evaluation data.

The relevant level flight performance guarantees are listed below by model specification paragraph number along with degree of compliance (Reference a):

<u>ITEM</u>	<u>COMPLIANCE</u>
3.1.2.1.7 Payload for 100-nautical mile radius at 34,000 pounds STOL weight at sea level (SL)	The guarantee calls for a payload of 7994 pounds. The CV-7A meets this requirement. At a STOL weight of 34,666 pounds the CV-7A can carry an 8550-pound payload on this mission.

ITEM

COMPLIANCE

3.1.2.2.6 V_{max}, Level Flight
true airspeed, SL
standard day two
engines at MRP

The guarantee calls for an airspeed of 233 knots. The CV-7A meets this requirement within the 3 percent allowable margin. The CV-7A will attain the placard airspeed limit of 230 knots at a lower power setting than MRP.

3.1.2.2.7 V_{max}, Level Flight
true airspeed, SL
standard day two
engines at NRP

The guarantee calls for an airspeed of 222 knots. The CV-7A exceeds this guarantee. Extrapolated data indicates the CV-7A can fly at 230 knots under guarantee conditions.

3.1.2.2.11 Ferry Range in still air

Insufficient data was obtained during the evaluation to evaluate this guarantee.

The relevant level flight performance requirements of the QMR are listed below, along with the degree of compliance (Reference g):

7. (U) Performance characteristics NASA sea level standard atmospheric conditions are applicable, no wind unless otherwise stated. Fuel allowance for reserve on landing is 10 percent of initial fuel load.

ITEM

COMPLIANCE

a. Missions

(1) normal mission
combat radius
100-nautical
mile, STOL

The CV-7A meets the essential requirements. The CV-7A can carry a payload of 8550 pounds on this mission while operating at a STOL gross weight (34,666 pounds).

(a) payload -
8000 pounds
(essential)
(b) payload -
10,000 pounds
(desirable)

(2) alternate mission
combat radius
200-nautical miles

The CV-7A meets the essential requirements. The CV-7A can carry a payload of 6650 pounds on this mission while operating at a STOL gross weight (34,666 pounds).

(a) payload -
6000 pounds
(essential)
(b) payload
8000 pounds
(desirable)

(3) (a) ferry mission

Insufficient data was obtained during the program to evaluate this requirement.

e. Maximum airspeed 200
knots (essential) at
maximum STOL gross
weight and MRP

The CV-7A easily meets this requirement. The CV-7A can achieve the placard airspeed (230 knots) at sea level under these conditions with a NRP setting.

Maximum airspeed
225 knots
(desirable)

2.4.2 CLIMB AND DESCENT

2.4.2.1 Objective

The objective of the climb and descent performance tests was to determine the optimum climb schedule and the maximum rates of climb and service ceilings for the CV-7A under both one and two engine operation. A single maximum rate descent was made from 25,000 feet to approximately 4000 feet to determine the minimum time required to descend from the ferry mission cruise altitude.

2.4.2.2 Method

The climb schedule and maximum rate of climb were determined by using the sawtooth climb method. The sawtooth climb technique involves timing a climb through a predetermined altitude band while flying successive data points at various airspeeds. The climb schedule obtained was verified by flying a check climb to the Operator's Manual limit altitude of 25,000 feet.

Tests were conducted with two engines operating at an average gross weight of 38,000 pounds at density altitudes of 5000, 10,000, and 15,000 feet. Single-engine climbs were conducted at the same gross weight at altitudes of 5000 feet and 10,000 feet. Single-engine climbs were flown at MRP settings, while two-engine climbs were flown at NRP settings. Standard day power was obtained from the engine Model Specification (Reference b).

2.4.2.3 Results

The results of the climb tests are presented graphically in Figures 51 through 53, Appendix I.

2.4.2.4 Analysis

The CV-7A, even at the maximum takeoff gross weight, exhibited excellent climb performance. A rate of climb of 600 feet per minute was observed during

the check climb at 25,000 feet, and 37,400 pounds when the climb was terminated. The limited single-engine climbs conducted showed excellent single-engine capability. At a gross weight of 37,800 pounds and an altitude of 10,000 feet, a single-engine rate of climb of 400 feet per minute was observed. Extrapolated data indicates a single-engine service ceiling of approximately 14,500 feet at a gross weight of 37,800 pounds.

The climb schedule determined in this evaluation was consistently approximately 5 knots faster than that presented in the Operator's Manual. The flatness of the "bucket" on the power required curves for the CV-7A made it unnecessary to hold an exact climb schedule to achieve maximum performance. The steep climb attitude at low airspeeds (approximately 15 knots lower than recommended) resulted in a decreased field of vision. Visibility during a climb at the recommended climb airspeeds was adequate.

A maximum rate descent was made from 25,000 feet to 4000 feet by holding the placard limit airspeed and flight idle power throughout the descent. This descent at a gross weight of 36,000 pounds took a total time of 6 minutes.

The maximum rate of climb for the CV-2B at sea level at maximum gross weight (28,500 pounds) was 1200 feet per minute. The CV-7A at its maximum gross weight (38,500 pounds) could maintain a rate of climb of 2250 feet per minute under the same conditions.

Flight tests that would adequately define compliance with all of the climb guarantees contained in the Model Specification were not conducted during the evaluation. In particular, Items 3.1.2.2.1 and 3.1.2.2.2, which deal with rate of climb at takeoff power, could not be evaluated. The following tabulation presents estimates of the pertinent climb guarantee based on extrapolations of the limited climb data obtained:

<u>ITEM</u>	<u>COMPLIANCE</u>
3.1.2.2.2 Service ceiling at 30,000 feet Power, two at NRP standard day Useful load of 11,200 pounds (34,666 pounds gross weight)	The CV-7A presently has an Operator's Manual restricted altitude of 25,000 feet. The airplane is capable of a service ceiling well over 30,000 feet from a performance standpoint
3.1.2.2.2 Service ceiling of 16,500 feet Power, one at MRP standard day Useful load of 11,208 pounds (34,666 pounds gross weight)	The CV-7A should meet this guarantee although sufficient data was not obtained at this gross weight for an accurate determination

Compliance with the Model Specification climb performance guarantees will insure compliance with the less stringent climb requirements of the QMR.

2.4.4 AIRSPEED CALIBRATION

2.4.4.1 Objective

The objective of these tests was to determine the position error of the ship airspeed system and to calibrate the test airspeed system.

2.4.2.2 Method

A calibrated trailing bomb was used to calibrate the airspeed system in level flight and STOL climbs and descents at airspeeds up to approximately 90 knots. The ground speed course method was used to calibrate the airspeed system for level flight airspeeds between 90 and 220 knots.

2.4.4.3 Results

The results of the airspeed calibration tests are presented in Figure 59, Appendix I.

2.4.4.4 Analysis

The airspeed position error for all configurations tested was less than 5 knots and was acceptable.

SECTION 3
APPENDIX I - TEST DATA

FIGURE NO 1
 SHORT FIELD TAKEOFF PERFORMANCE SUMMARY
 CV-7A RUNWAY SURFACE - DRY ASPHALT OR DRY CONCRETE
 USA S/N 63-13687
 US STANDARD DAY
 ZERO WIND

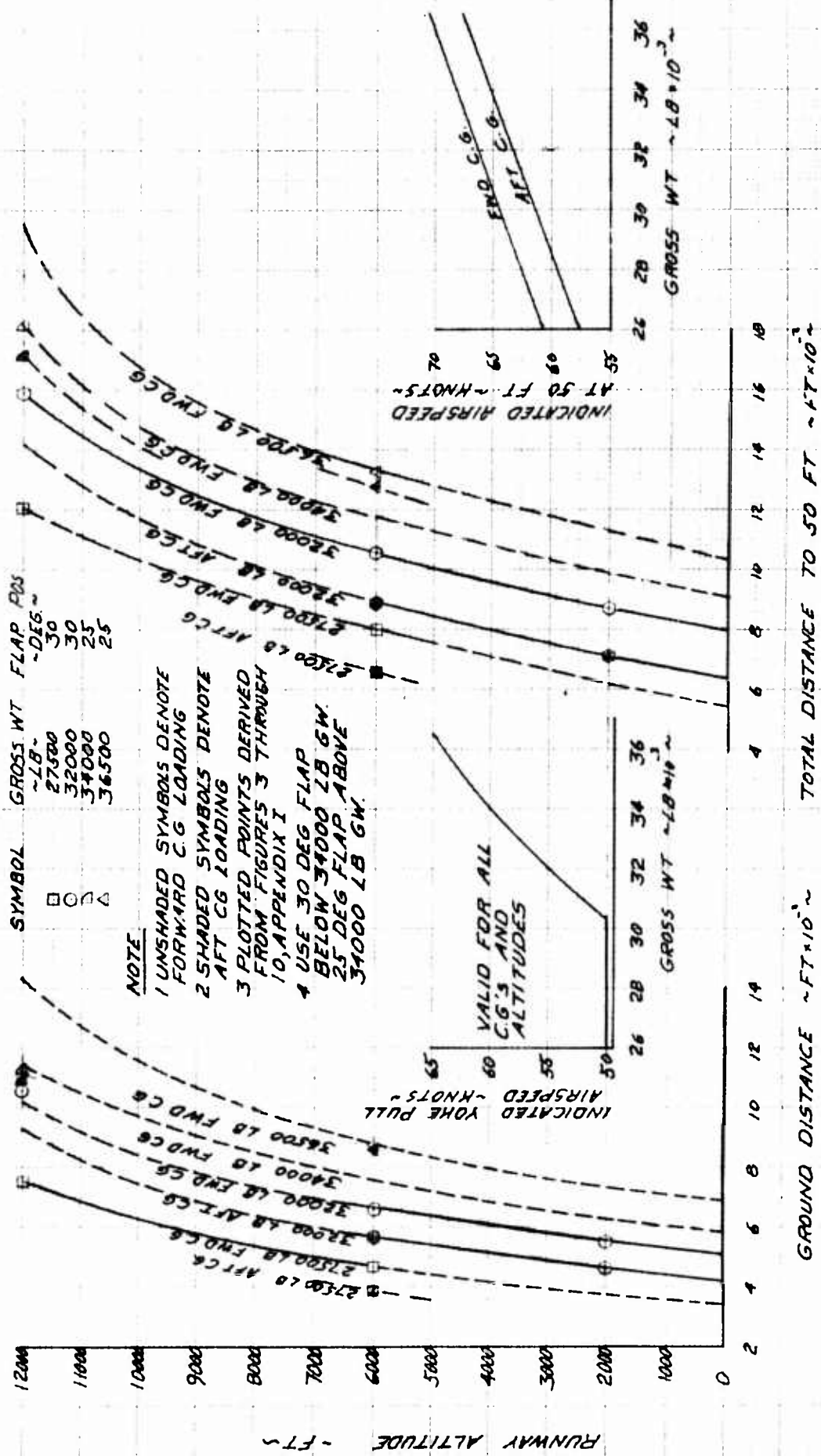


FIGURE No 2 SHORT FIELD TAKEOFF PERFORMANCE SUMMARY USA S/N 63-13687 CV-7A RUNWAY SURFACE - DRY ASPHALT

NOTE

TEST DATA CORRECTED TO:

1 US STANDARD DAY

2 ZERO WIND

3 T-64-10 MODEL SPECIFICATION (FIG 57)

4 TAKEOFF SHIP PRESENT 25 DEG FLAP PERFORMANCE. SOLID LINES 30 DEG FLAP

6000 FEET

FLAP POSITION

DEG

30

30

30

30

30

25

25

30

25

GROSS WEIGHT

~LB~

27500

27500

32000

32000

34000

34000

36500

36500

SYMBOL

△

○

◇

▽

▲

△

▲

37000

36000

35000

34000

33000

32000

31000

30000

29000

28000

27000

GROSS WEIGHT

~LB~

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

25 DEG FLAPS

RECOMMENDED FLAP

SETTING ABOVE 34000

LB - 25 DEG.

BELOW 34000

LB - 30 DEG.

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

30 DEG FLAPS

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

FWD C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

AFT C.G.

GROUND DISTANCE ~ FEET~

GROUND DISTANCE ~ FEET~

GROUND DISTANCE ~ FEET~

GROUND DISTANCE ~ FEET~

GROUND DISTANCE ~ FEET~

GROUND DISTANCE ~ FEET~

GROUND DISTANCE ~ FEET~

GROUND DISTANCE ~ FEET~

GROUND DISTANCE ~ FEET~

TOTAL DISTANCE TO 50 FEET ~ FEET~

TOTAL DISTANCE TO 50 FEET ~ FEET~

TOTAL DISTANCE TO 50 FEET ~ FEET~

TOTAL DISTANCE TO 50 FEET ~ FEET~

TOTAL DISTANCE TO 50 FEET ~ FEET~

TOTAL DISTANCE TO 50 FEET ~ FEET~

TOTAL DISTANCE TO 50 FEET ~ FEET~

TOTAL DISTANCE TO 50 FEET ~ FEET~

TOTAL DISTANCE TO 50 FEET ~ FEET~

Figure No 3
SHORT FIELD TAKEOFF PERFORMANCE
CV-7A USA NH 63-13687
RUNWAY SURFACE - DRY CONCRETE
2000 FT

NOTE
 TEST DATA CORRECTED TO
 1. U.S. STANDARD DAY
 2. ZERO WIND
 3. T-6E-10 MODEL SPECIFICATION
 TAKE OFF SHF_{max} (FIG 87)

SYM	GROSS WT ~LB~	C.G. ~INCH~	FLAP POS ~DEG~
○	32000	242 (FWD)	30
□	32000	212 (AFT)	30

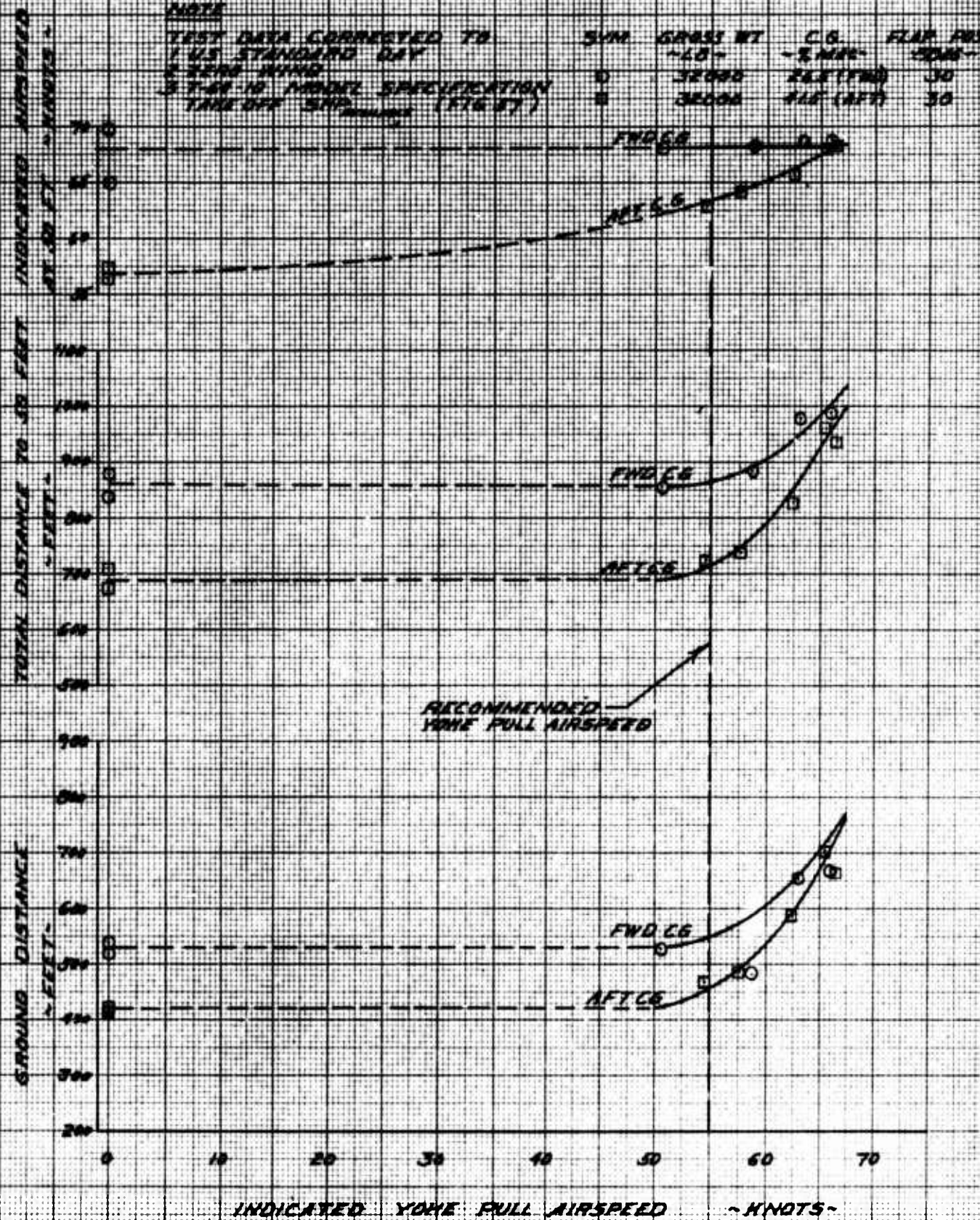


FIGURE No 4
SHORT FIELD TAKEOFF PERFORMANCE
CV-74 **USA S/N 43-13487**
RUNWAY SURFACE - DRY ASPHALT
6000 FT

NOTE

TEST DATA CORRECTED TO:

1 U.S. STANDARD DAY

2 ZERO WIND

3 T-64-10 MODEL SPECIFICATION
 TAKEOFF SNR AVAILABLE (FIG 57)

SYM	GROSS WT -LB-	C.G. -%MAC-	FLAP PRE -DEG-
○	27500	28.5 (FWD)	30
□	27500	41.5 (AFT)	30

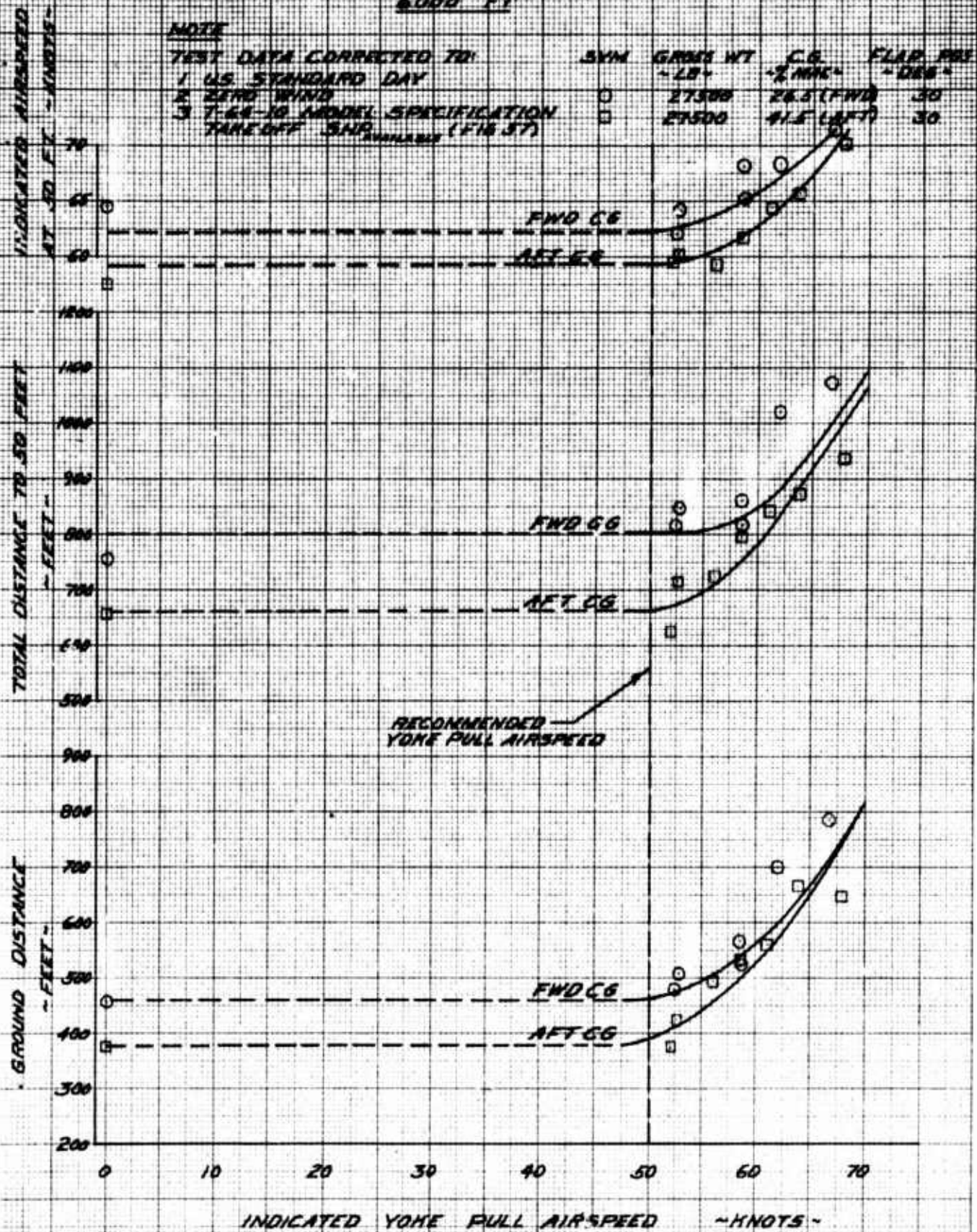


FIGURE NO 5
 SHORT FIELD TAKEOFF PERFORMANCE
 CV-7A USA S/N 63-13687
 RUNWAY SURFACE - DRY ASPHALT
 6000 FT

NOTE

TEST DATA CORRECTED TO:
 1 U.S. STANDARD DAY
 2 ZERO WIND
 3 T-64-10 MODEL SPECIFICATION
 TAKEOFF SHP AVAILABLE (FIG 57)

SYM	GROSS WT ~LB~	C.G. ~%MAC~	FLAP POS ~DEG~
○	32000	26.5 (FWD)	30
□	32000	41.5 (AFT)	30

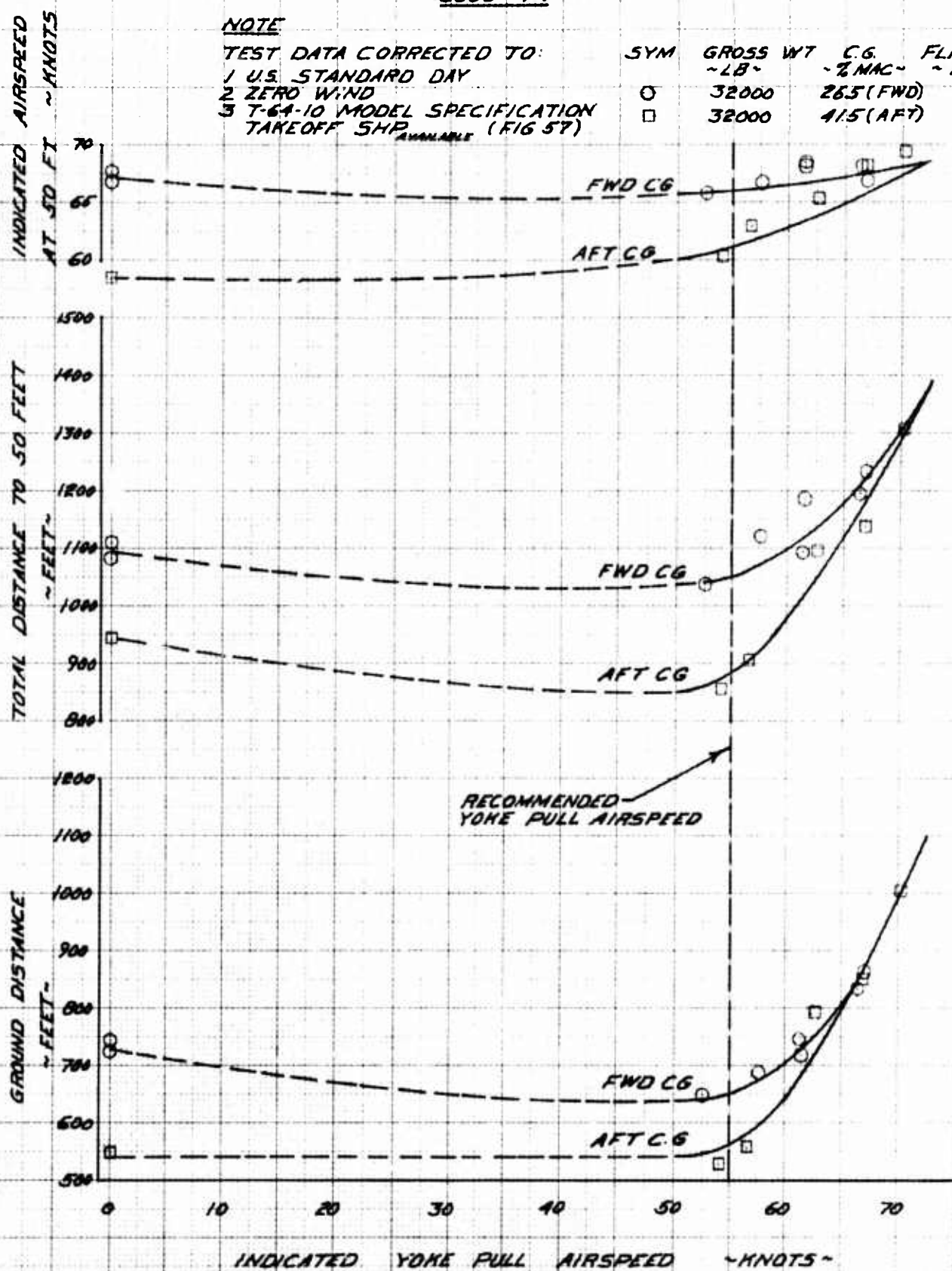


FIGURE No 6
SHORT FIELD TAKEOFF PERFORMANCE
CV-7A **USA SIN 63-13687**
RUNWAY SURFACE - DRY ASPHALT
6000 FT

NOTE

TEST DATA CORRECTED TO:
 1 US STANDARD DAY
 2 ZERO WIND
 3 T-64-10 MODEL SPECIFICATION
 TAKE OFF SHP AVAILABLE (FIG 57)

SYM	GROSS WT ~LB~	C.G. ~%MAC~	FLAP POS ~DEG~
○	32000	26.5(FWD)	25
□	32000	28.5(FWD)	35

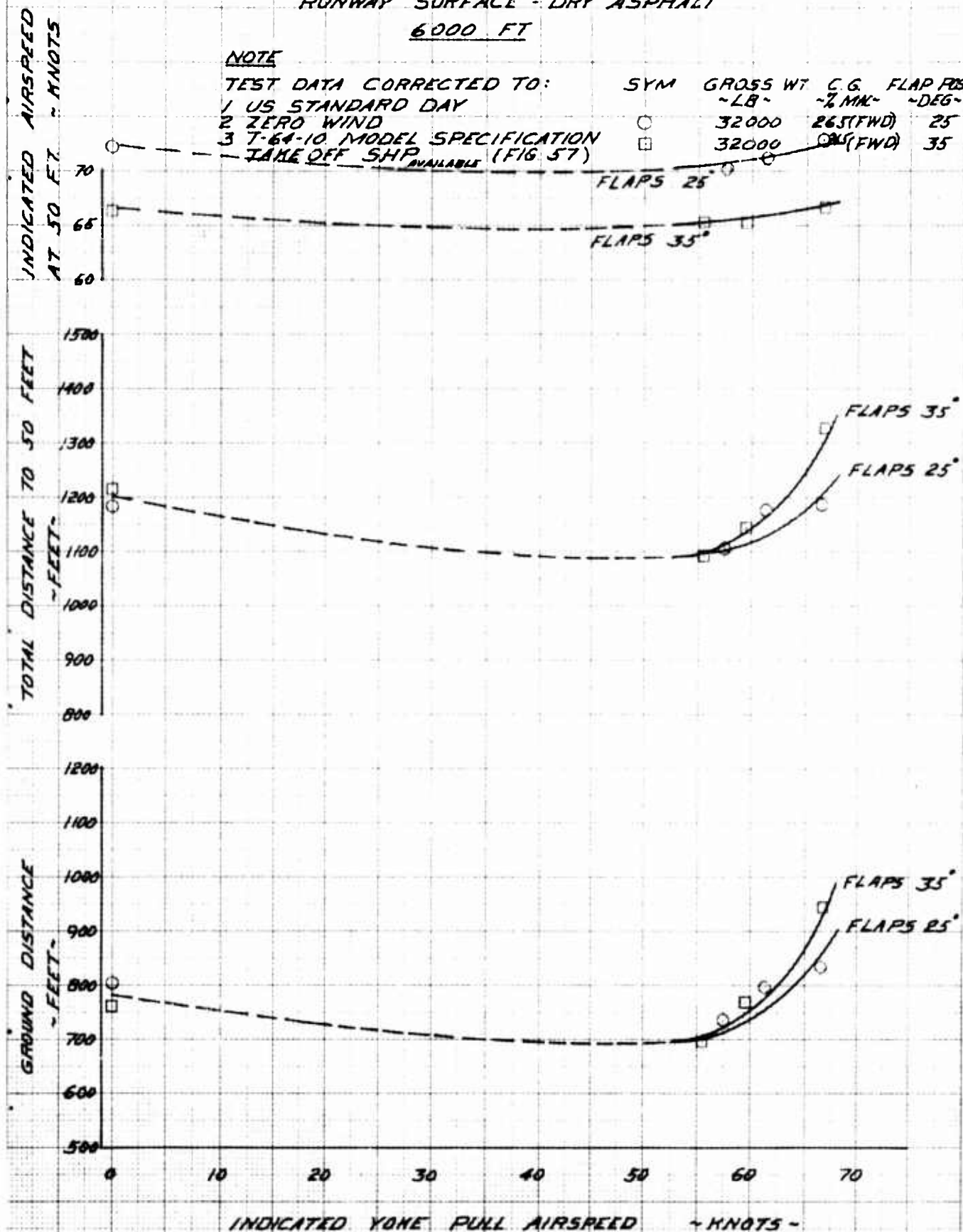


FIGURE NO 7
SHORT FIELD TAKEOFF PERFORMANCE
CV-7A **USA S/N 63-13687**
RUNWAY SURFACE - DRY ASPHALT
6,000 FT

NOTE

TEST DATA CORRECTED TO:
 1 US STANDARD DAY
 2 ZERO WIND
 3 T-64-10 MODEL SPECIFICATION
 TAKE OFF SHP AVAILABLE (FIG 57)

SYM	GROSS WT ~LB~	C.G. ~%MAC~	FLAP POS ~DEG~
○	34000	32.3 (MID)	30
□	34000	32.6 (MID)	25

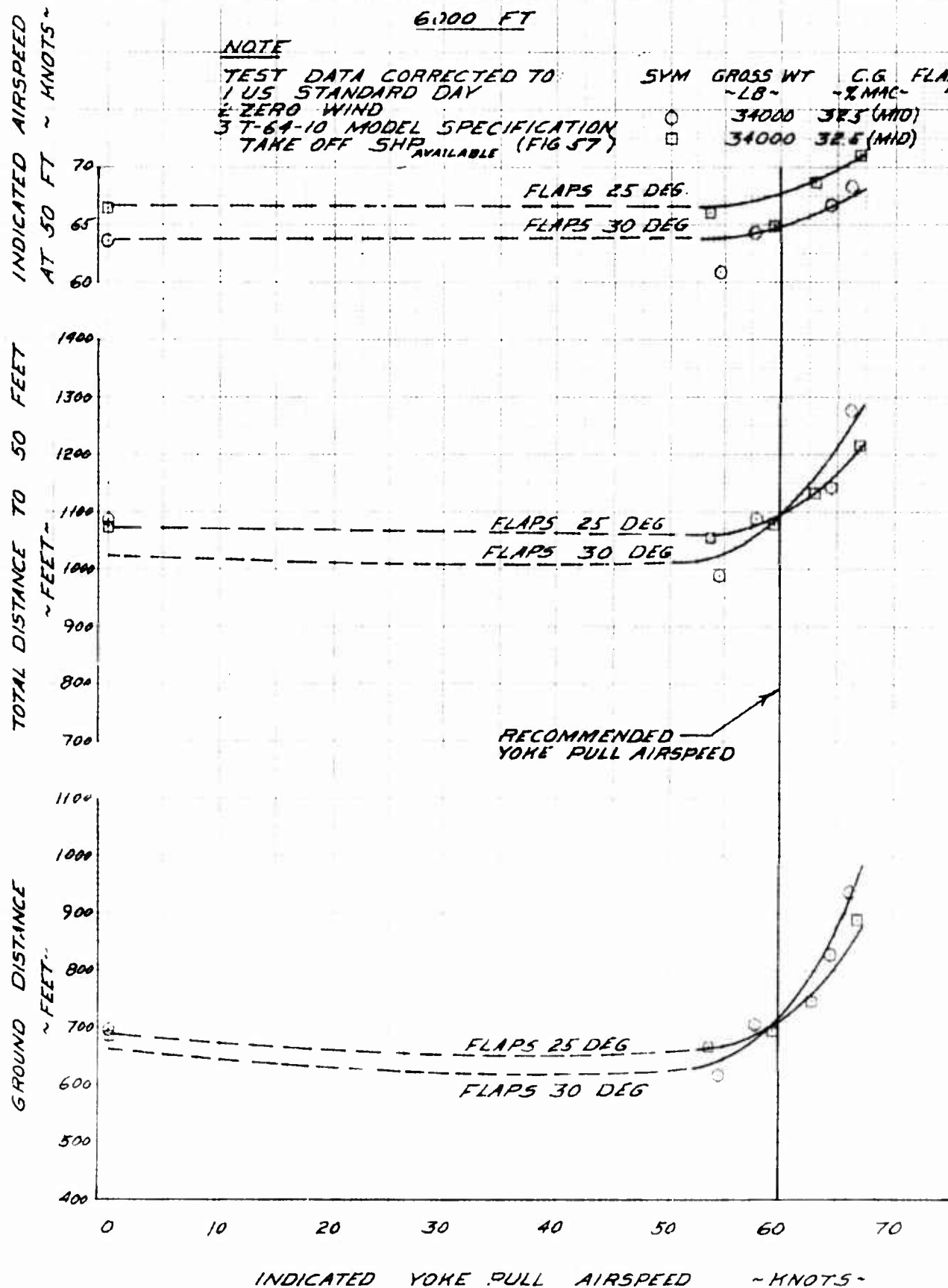


FIGURE No 8
 SHORT FIELD TAKEOFF PERFORMANCE
 CV-7A
 USA SIN 63-13687
 RUNWAY SURFACE - DRY ASPHALT
 6000 FT

NOTE

TEST DATA CORRECTED TO:
 1. U.S. STANDARD DAY
 2. ZERO WIND
 3. T-64-10 MODEL SPECIFICATION
 TAKE-OFF SHP AVAILABLE (FIG. 57)

SYM.	GROSS WT ~LB~	C.G. ~% MAC~	FLAP POS. ~DEG~
○	36500	26.5 (FWD)	30
□	36500	26.5 (FWD)	25
△	36500	41.5 (AFT)	25

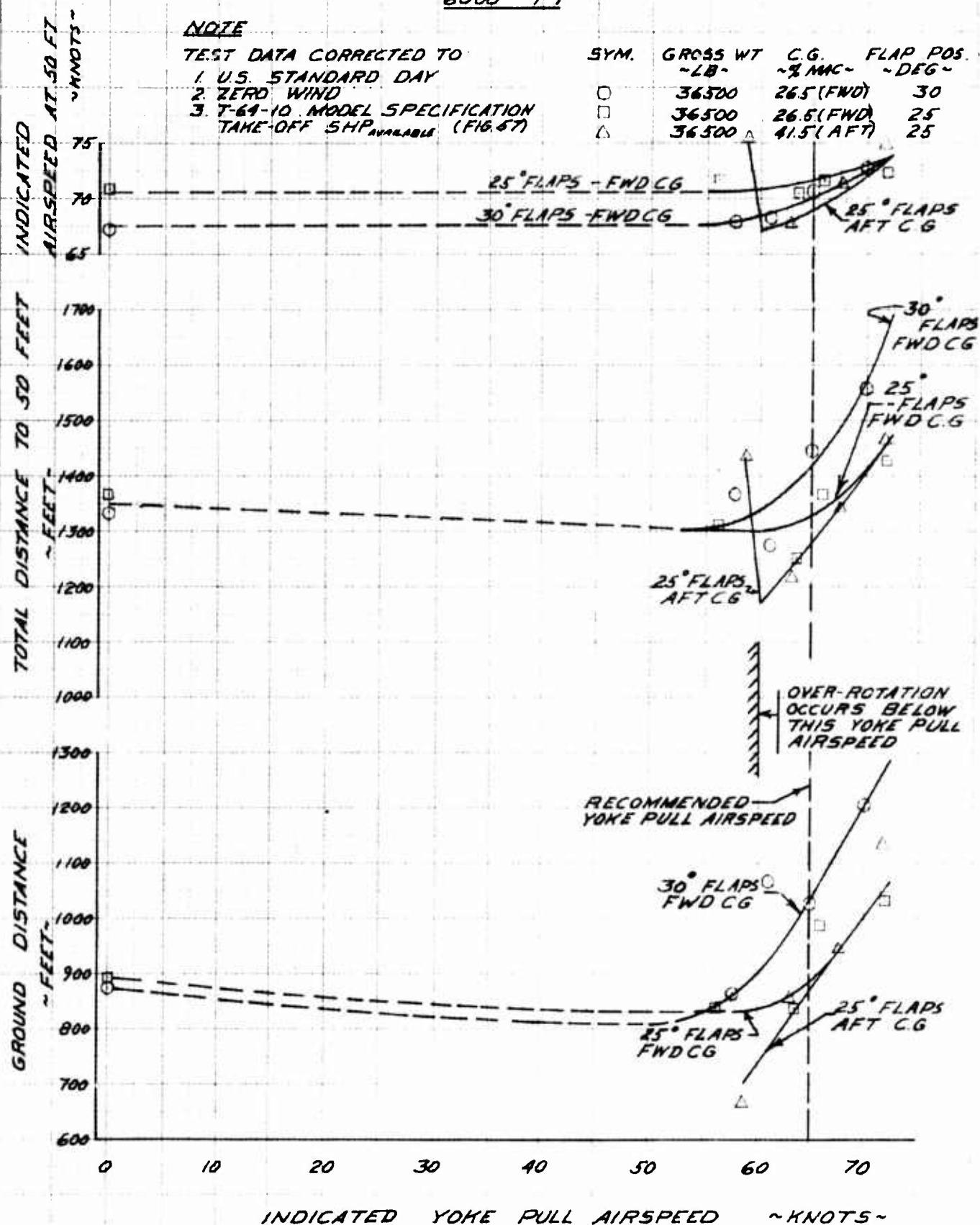


FIGURE No 9
SHORT FIELD TAKEOFF PERFORMANCE
CV-7A **USA S/N 63-13687**
RUNWAY SURFACE - DRY ASPHALT
12000 FT

NOTE

TEST DATA CORRECTED TO:

- 1 US STANDARD DAY
- 2 ZERO WIND
- 3 T-64-10 MODEL SPECIFICATION
TAKEOFF SHP AVAILABLE (FIG 37)

SYM	GROSS WT ~LB~	CG ~% MAC~	FLAP POS ~DEG~
○	27500	26.5 (FWD)	30
□	32000	26.5 (FWD)	30
△	32000	26.5 (FWD)	25

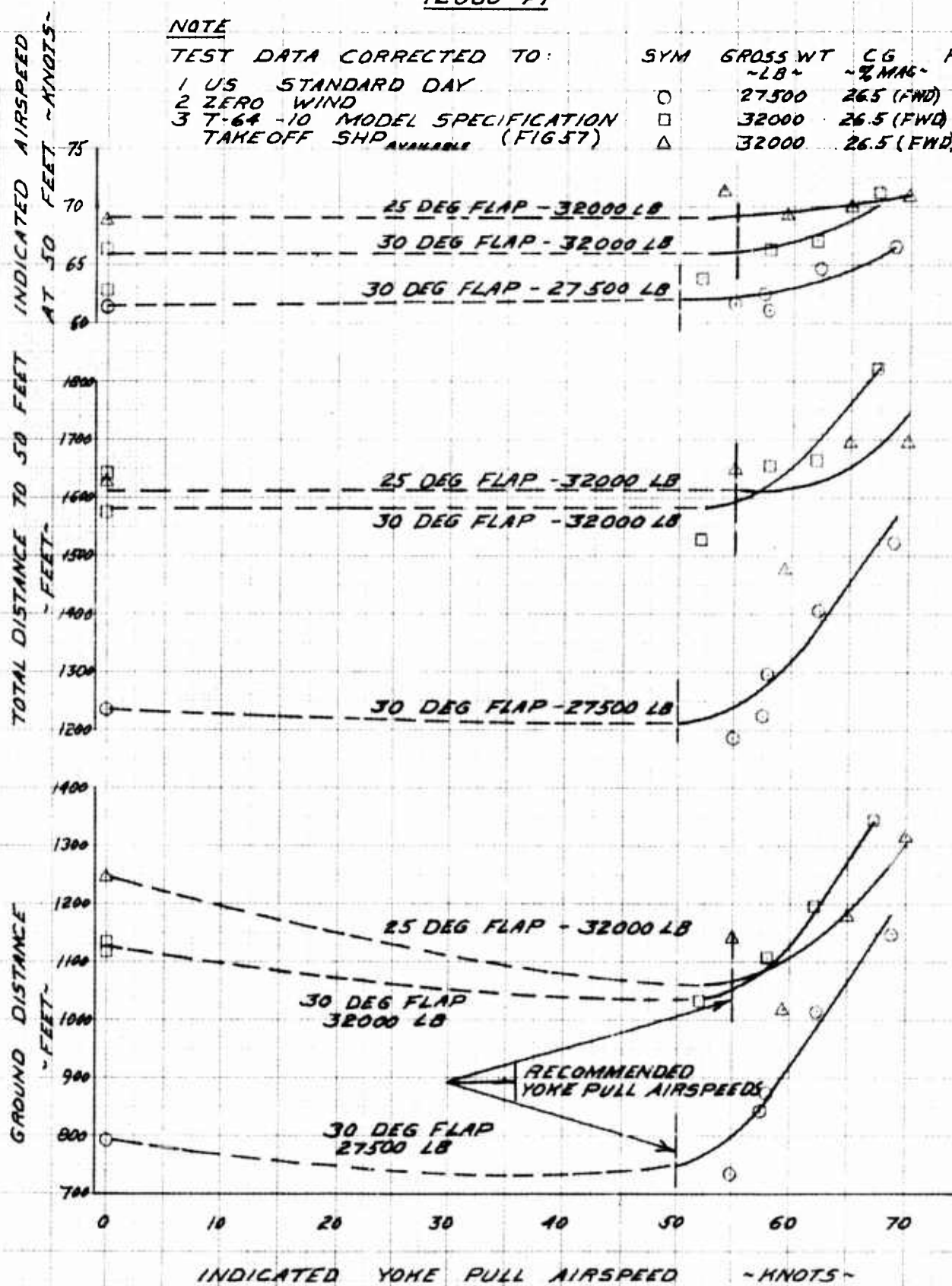


FIGURE No 10
SHORT FIELD TAKEOFF PERFORMANCE
CV-7A **USA S/N 63-13687**
RUNWAY SURFACE - DRY ASPHALT
12000 FT

NOTE

TEST DATA CORRECTED TO:
 1 US STANDARD DAY
 2 ZERO WIND
 3 T-64-10 MODEL SPECIFICATION
 TAKE OFF SNP AVAILABLE (FIG 57)

SYM	GROSS WT ~LB~	C.G. ~INAC~	FLAP POS ~DEG~
○	34000	285 (FWD)	25
□	34000	415 (AFT)	25

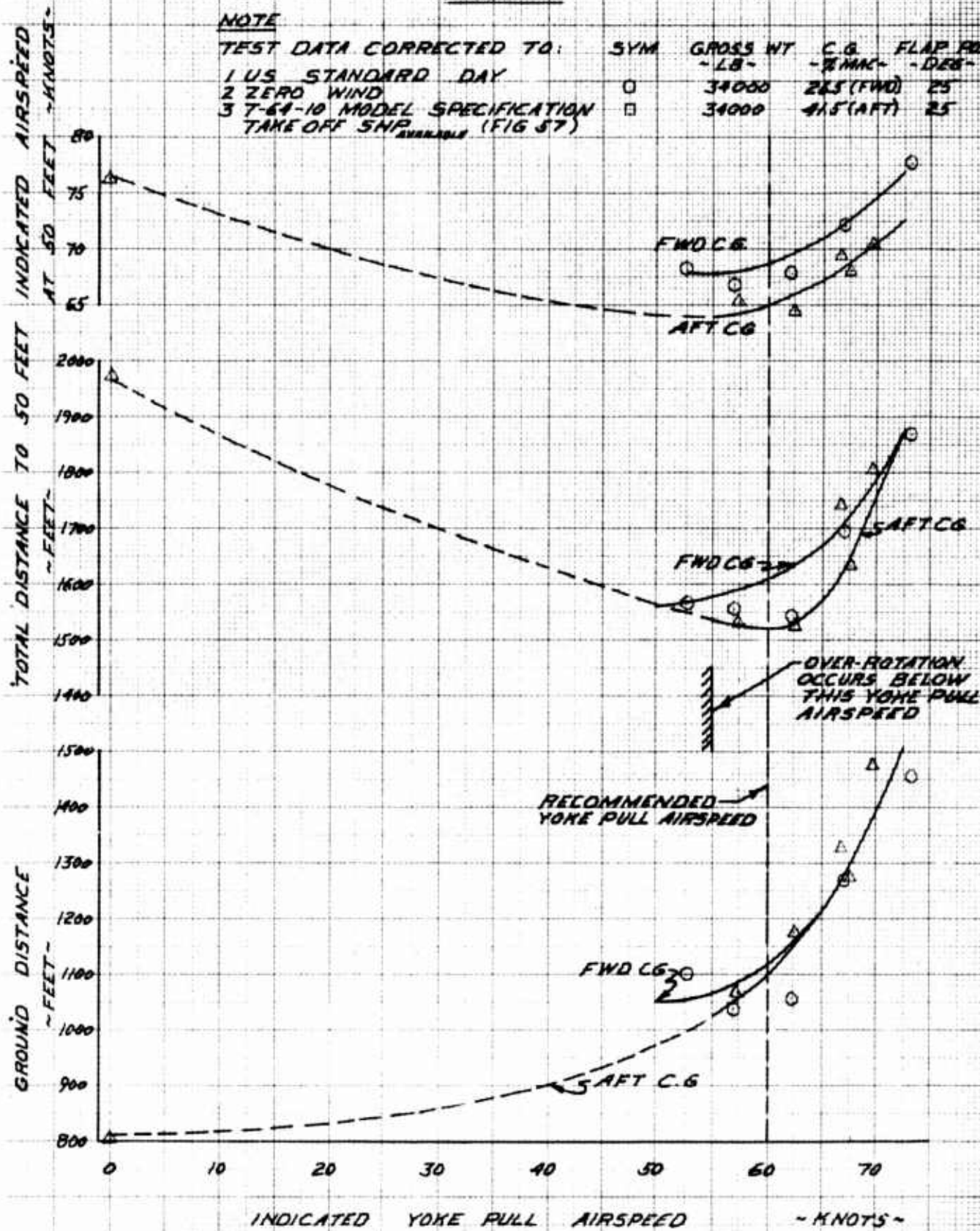


FIGURE No 11

SHORT FIELD LANDING PERFORMANCE SUMMARY

CV-7A

USA 51N 63-13687

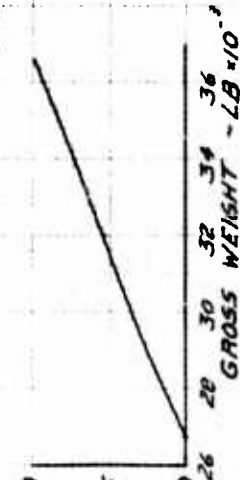
US STANDARD DAY

ZERO WIND

DRY CONCRETE OR ASPHALT RUNWAY

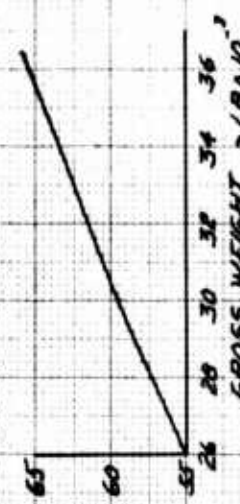
RECOMMENDED MINIMUM
50 FT INDICATED AIRSPEED
- KNOTS -

60 65 70



NOMINAL IAS
AT TOUCHDOWN
- KNOTS -

55 60 65

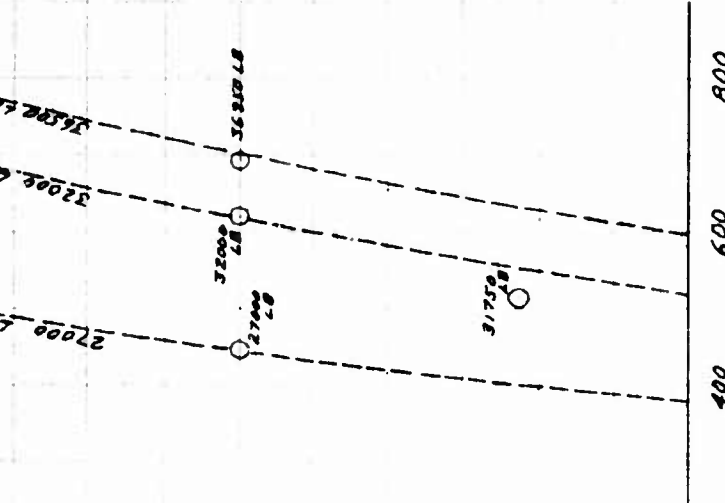


NOTE

1. PLOTTED POINTS DERIVED FROM FIGURES 12 THROUGH 15, APPENDIX I
2. TEST AVERAGE GROSS WEIGHT PRINTED NEXT TO EACH POINT
3. FLIGHT TEST TECHNIQUE UTILIZED
 - A) FLAPS - FULL DOWN
 - B) POWER - FLIGHT IDLE
 - C) PROPELLER - APPROACH STOP
 - D) MAXIMUM REVERSE THRUST AFTER TOUCHDOWN
 - E) MODERATE BRAKING

RUNWAY ALTITUDE - FEET -

10000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0



GROUND ROLL - FEET -

TOTAL DISTANCE OVER 50 FEET - FEET -

600 800 1000 1200

34 36

FIGURE NO 12
SHORT FIELD LANDING PERFORMANCE
CV-7A **USA S/N 63-13687**

NOTE

TEST DATA CORRECTED TO:
 1 ZERO WIND
 2 U.S. STANDARD DAY

NOTE

FLIGHT TEST TECHNIQUE UTILIZED
 1 FLAPS - FULL DOWN
 2 POWER - FLIGHT IDLE
 3 PROPELLER - APPROACH STOP
 4 MAXIMUM REVERSE THRUST
 AFTER TOUCHDOWN
 5 MODERATE BRAKING

SYMBOL	ALTITUDE ~ FT ~	AVG GROSS WT ~ LB ~	RUNWAY SURFACE
O	2250	31750	DRY CONCRETE

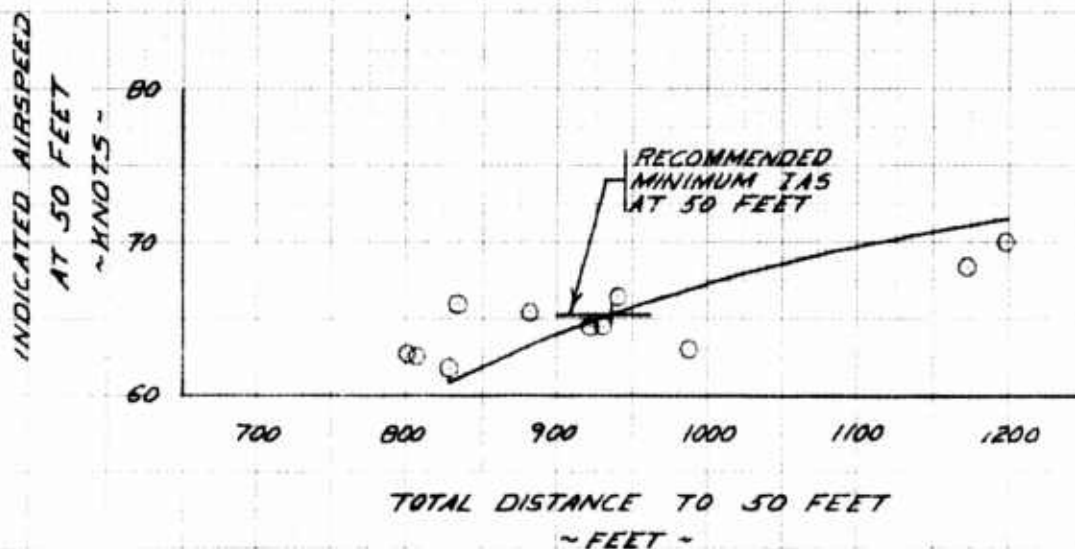
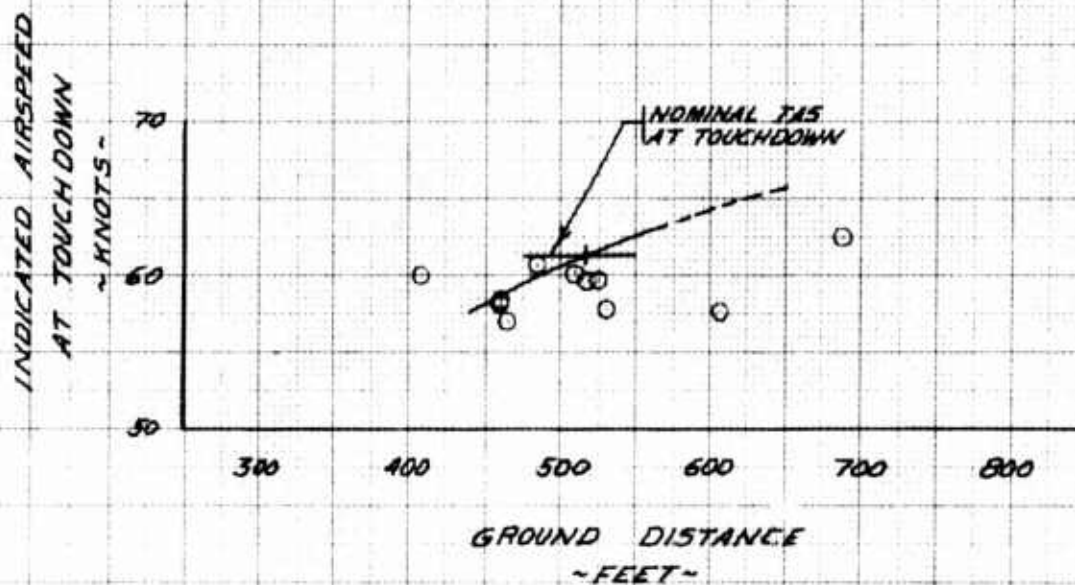


FIGURE No 13
SHORT FIELD LANDING PERFORMANCE
CV-7A **USA S/N 63-13687**

NOTE

TEST DATA CORRECTED TO:
 1 ZERO WIND
 2 US STANDARD DAY

NOTE

FLIGHT TEST TECHNIQUE UTILIZED
 1 FLAPS - FULL DOWN
 2 POWER - FLIGHT IDLE
 3 PROPELLER - APPROACH STOP
 4 MAXIMUM REVERSE THRUST
 AFTER TOUCHDOWN
 5 MODERATE BRAKING

SYMBOL	ALTITUDE ~ FT ~	AVG. GROSS WT ~ LB ~	RUNWAY SURFACE
○	6000	32000	DRY ASPHALT
△	6000	27000	DRY ASPHALT

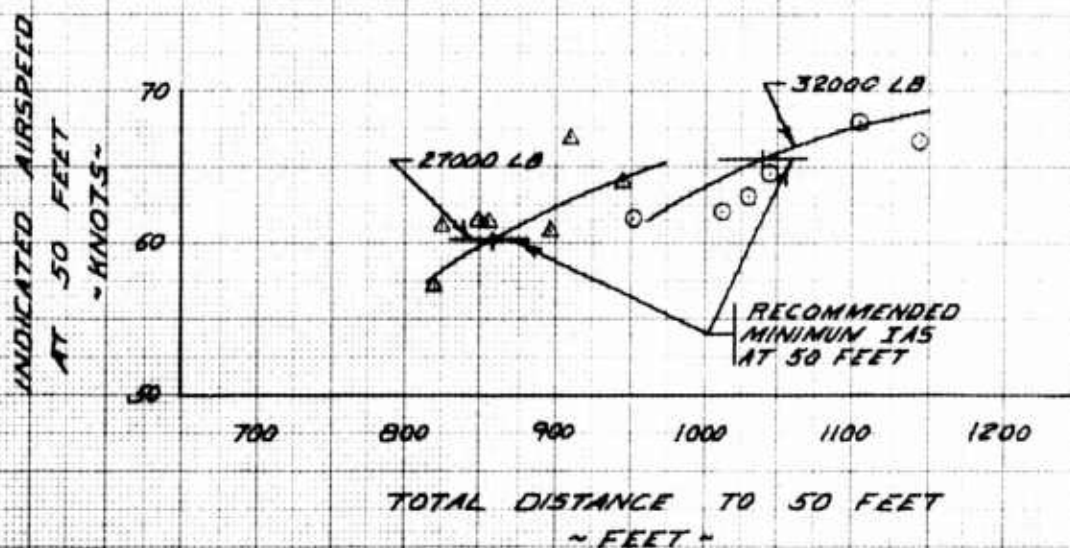
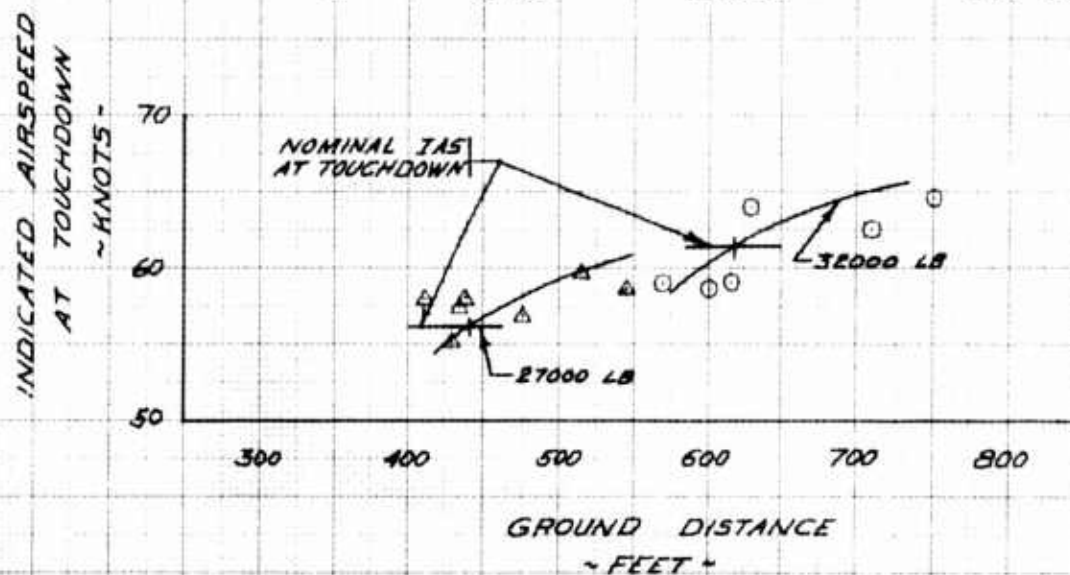


FIGURE NO 14
SHORT FIELD LANDING PERFORMANCE
CV-7A
USA SIN 63-13687

NOTE

TEST DATA CORRECTED TO:
1 ZERO WIND
2 US STANDARD DAY

NOTE

FLIGHT TEST TECHNIQUE UTILIZED
1 FLAPS - FULL DOWN
2 POWER - FLIGHT IDLE
3 PROPELLER - APPROACH STOP
4 MAXIMUM REVERSE THRUST
AFTER TOUCHDOWN
5 MODERATE BRAKING

SYMBOL	ALTITUDE ~ FT ~	AVG GROSS WT ~ LB ~	RUNWAY SURFACE
○	6000	36250	DRY ASPHALT

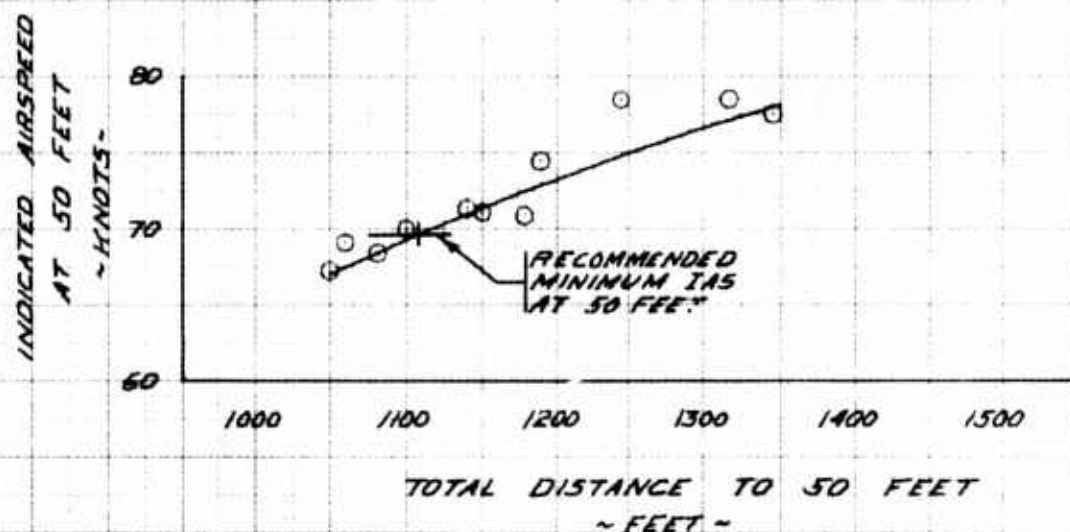
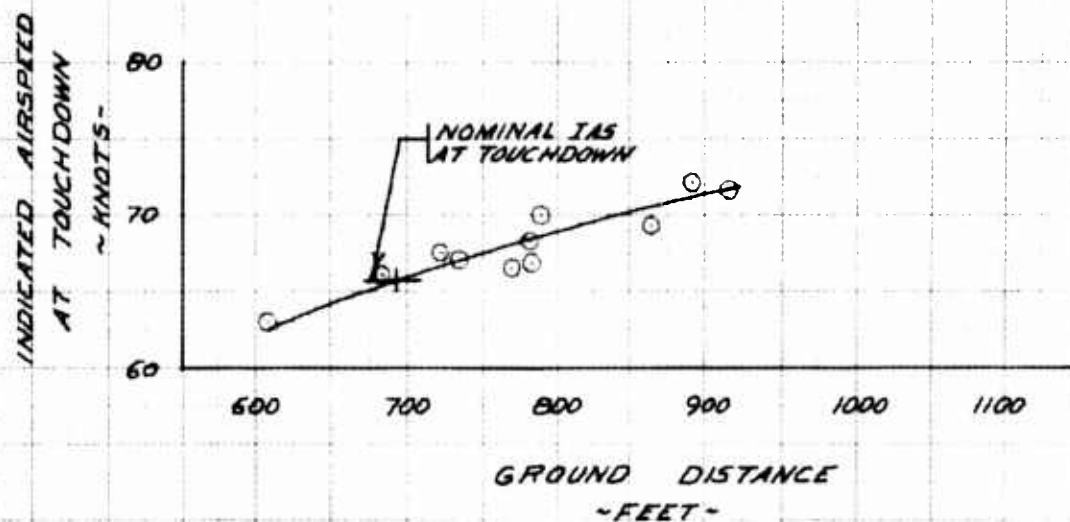


FIGURE NO 15
SHORT FIELD LANDING PERFORMANCE
CV-7A **USA S/N 63-13687**

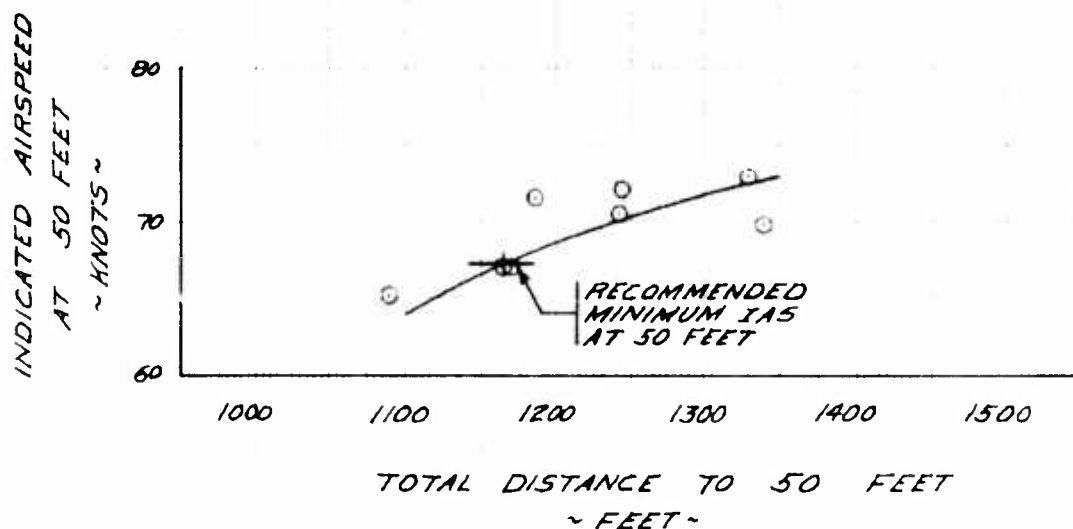
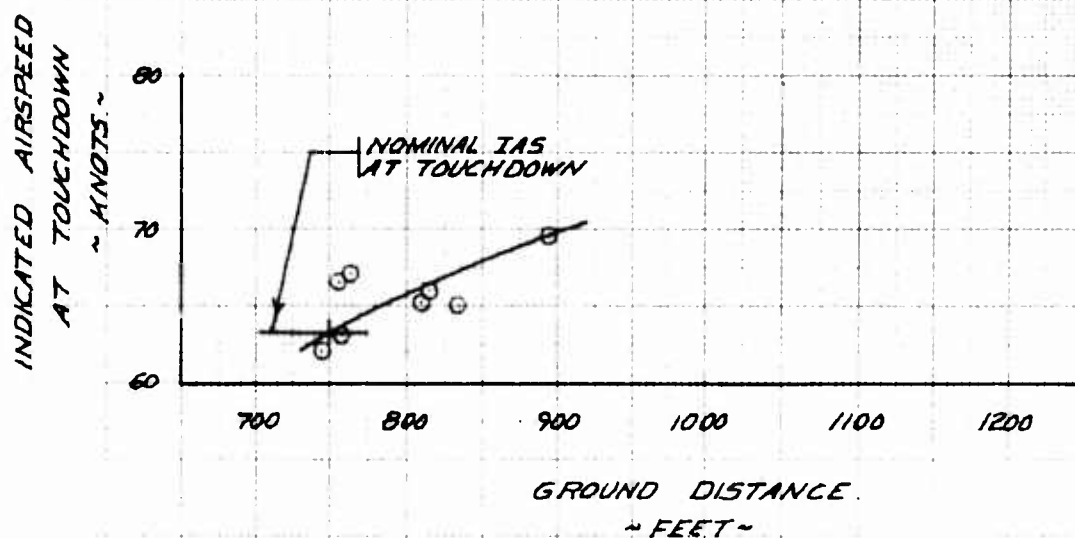
NOTE

TEST DATA CORRECTED TO:
 1 ZERO WIND
 2 US STANDARD DAY

NOTE

FLIGHT TEST TECHNIQUE UTILIZED
 1 FLAPS - FULL DOWN
 2 POWER - FLIGHT IDLE
 3 PROPELLER - APPROACH STOP
 4 MAXIMUM REVERSE THRUST
 AFTER TOUCHDOWN
 5 MODERATE BRAKING

SYMBOL	ALTITUDE ~ FT ~	AVG GROSS WT ~ LB ~	RUNWAY SURFACE
O	9500	34 000	DRY ASPHALT

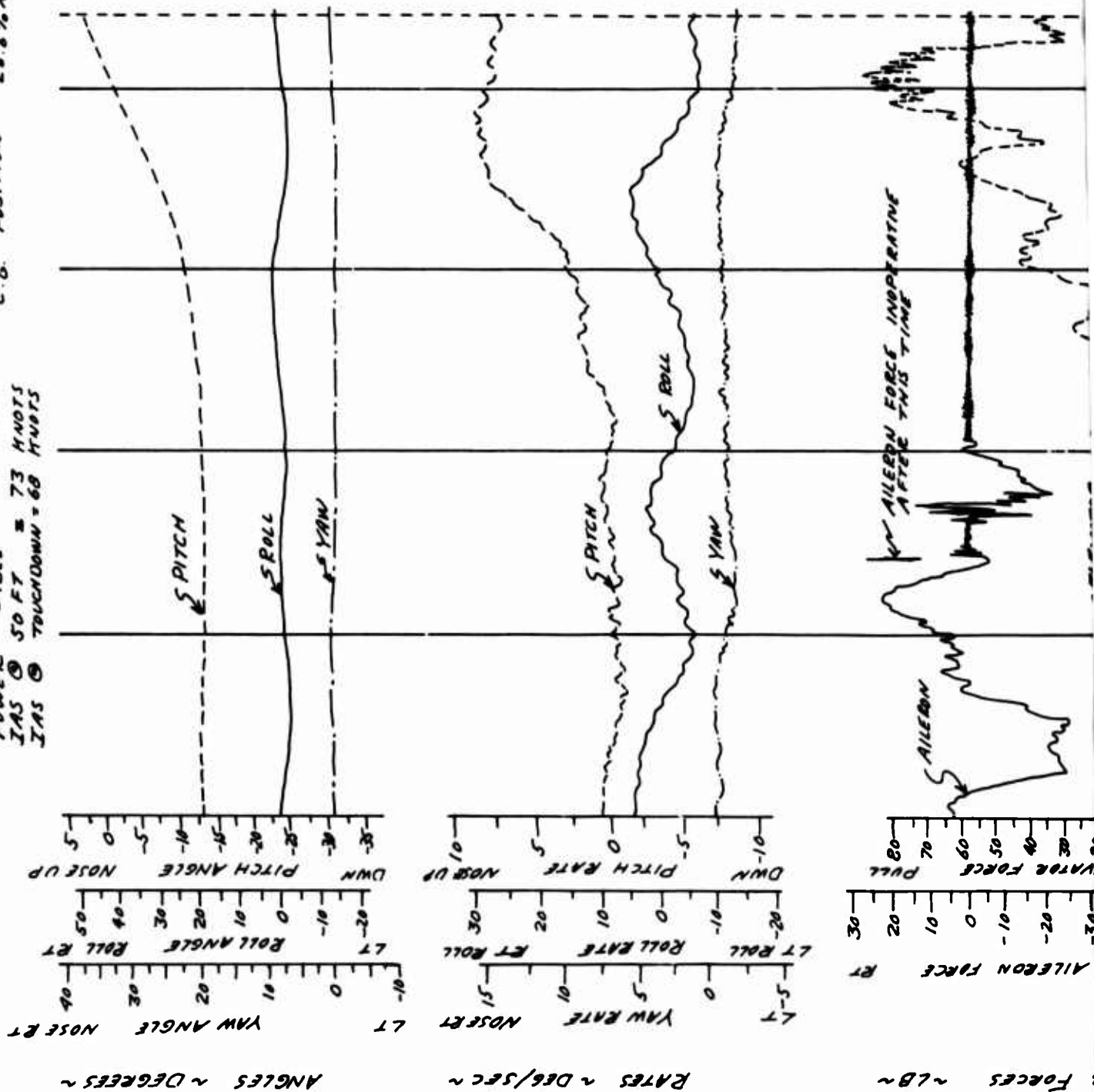


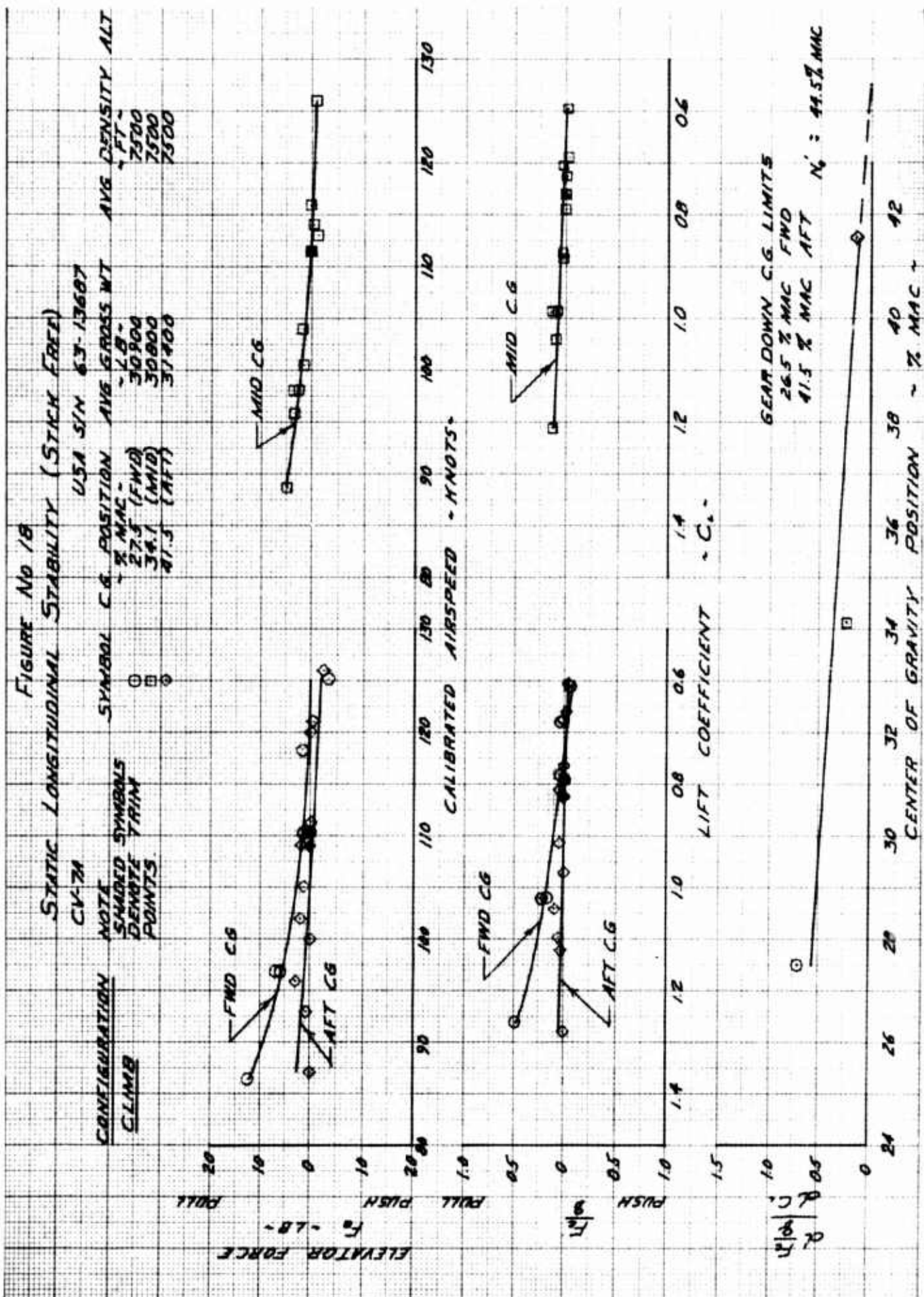


2

FIGURE No. 16

TURBULENT AIR STOL LANDING
 CV-7A USA SN 63-13687
 WIND GUSTING FROM 5 TO 20 KNOTS
 DENSITY ALTITUDE = 11,000 FT GROSS WEIGHT 32,400 LB
 POWER ~ IDLE C.G. POSITION 26.6% MAC (FWD)
 IAS @ 50 FT = 73 KNOTS
 IAS @ TOUCHDOWN = 68 KNOTS





Previous pages were blank, therefore not filmed.

FIGURE No 19
STATIC LONGITUDINAL STABILITY (STICK FIXED)

CV-7A

USA S/N 63-13687
AVG GROSS WT ~LB~
AVG DENSITY ALT ~FT~

8500
8200
7700
8300
7800

C.G. POSITION
~% MAC~
26.8 (FWD)
34.1 (MID)
41.6 (AFT)
26.5 (FWD)
42.2 (AFT)

SYMBOL
○ □ ◇ ▽

NOTE
SHADED SYMBOLS
DENOTE TRIM
POINTS

CONFIGURATION
POWER APPROACH
STOL
FLAPS 40 DEG
POWER FOR LEVEL FLIGHT

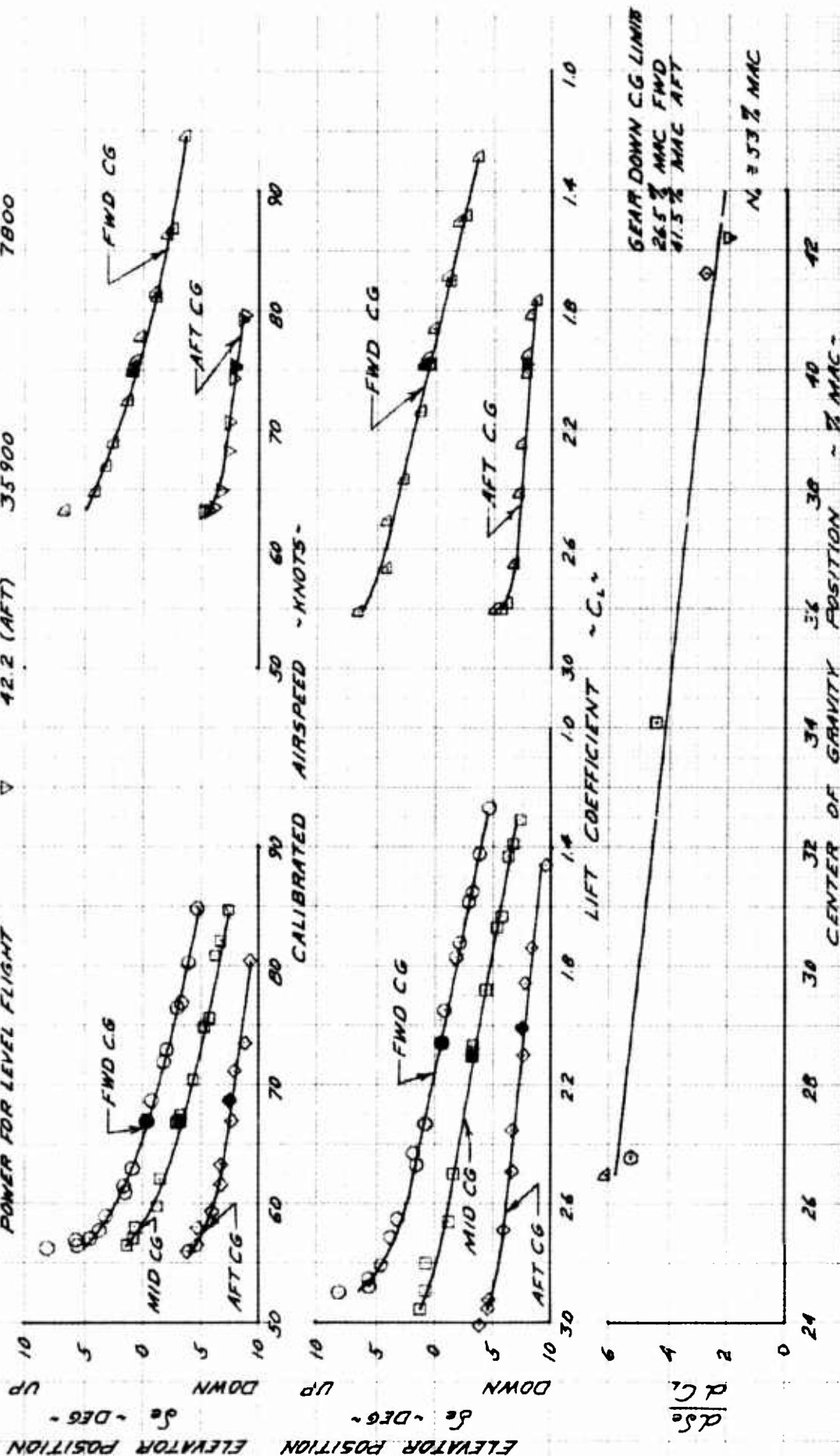


FIGURE No 20
STATIC LONGITUDINAL STABILITY (Stick Free)
CV-7A

CONFIGURATION	POWER APPROACH	NOTE	SYMBOL	C.G. POSITION ~% MAC	AVG GROSS WT ~LB	AVG DENSITY ALT ~FT
STOL	FLAPS 40 DEG	SHADED SYMBOLS DENOTE POINTS FOR LEVEL FLIGHT	○	26.8 (FWD)	29500	8500
			□	34.1 (MID)	30000	8200
			◇	41.6 (AFT)	30300	7700
			△	26.5 (FWD)	36100	8300
				42.2 (AFT)	35900	7800

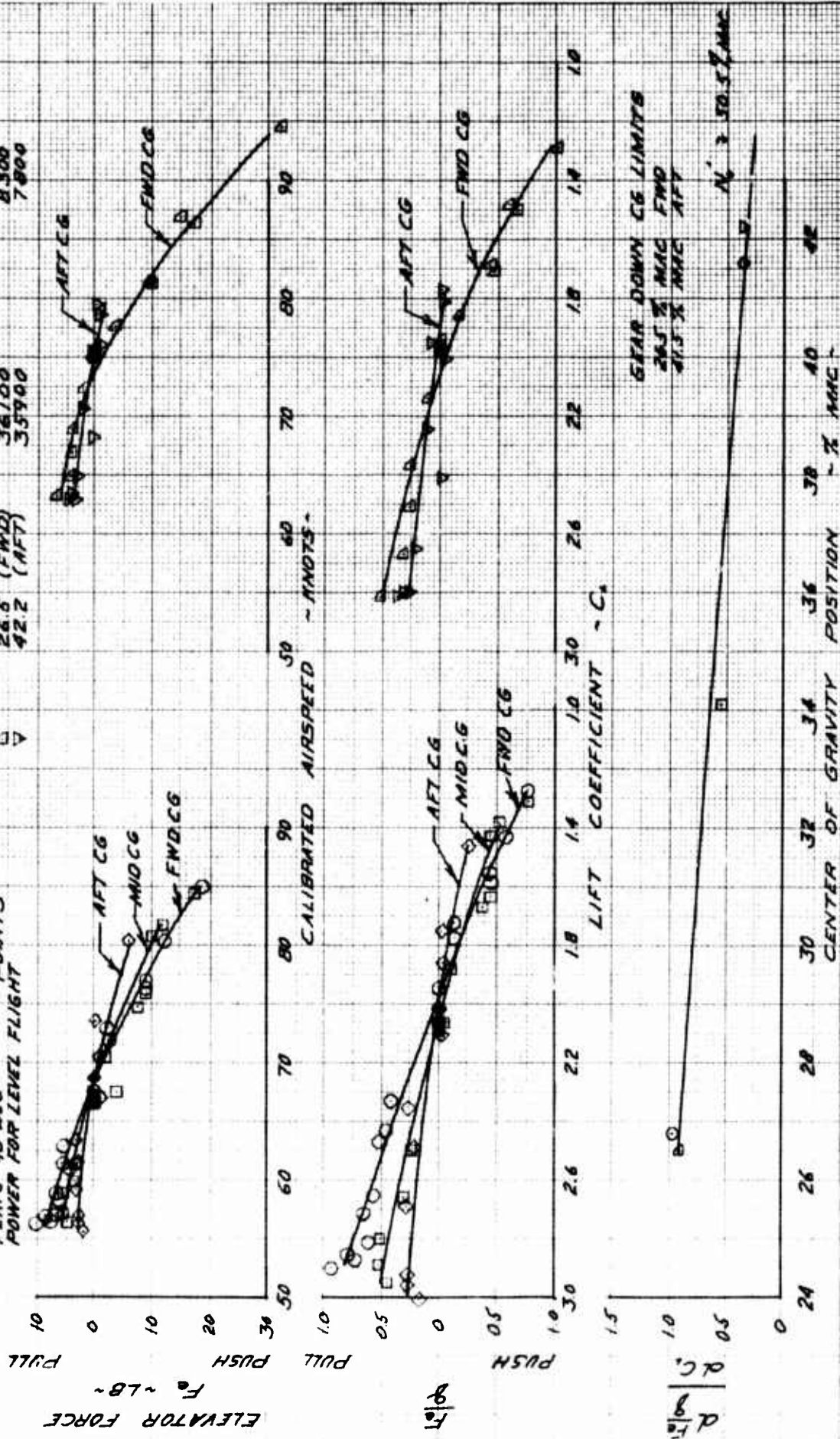


Figure No 21
STATIC LONGITUDINAL STABILITY (STION FIXED)

CV-24

CONFIGURATION

STOL LANDING

FLAPS 40 DEG

IDLE POWER

NOTE

SHARDED SYMBOLS

DEMONSTRATE

POINTS

SYMBOL

○

□

△

▽

C.G. POSITION AND GROSS WT

275 (FWHD)

341 (MID)

413 (AFT)

413 (AFT)

USA 51N 67 13000

275 (FWHD)

341 (MID)

413 (AFT)

413 (AFT)

AIR DENSITY REF

0.001

0.002

0.003

0.004

0.005

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

FWDCG

MIDCG

AFTCG

GEAR DOWN CG LIMITS

25.5% MAC FWDCG

41.3% MAC AFTCG

MAC 59.8

ELEVATOR POSITION
DOWN
UP
- 50 - DEG -

ELEVATOR POSITION
DOWN
UP
- 50 - DEG -

$\frac{dC_L}{d\delta}$

10
5
0
5
10

10
5
0
5
10

15
10
5
0

60
70
80
90
100

60
70
80
90
100

24
26
28
30
32
34
36
38
40
42

CALIBRATED AIRSPEED - KNOTS -

CALIBRATED AIRSPEED - KNOTS -

LIFT COEFFICIENT - C_L -

26
22
18
14

26
22
18
14

24
26
28
30
32
34
36
38
40
42

FWDCG

FWDCG

FWDCG

MIDCG

MIDCG

MIDCG

AFTCG

AFTCG

AFTCG

FWDCG

FWDCG

FWDCG

MIDCG

MIDCG

MIDCG

AFTCG

AFTCG

AFTCG

FWDCG

FWDCG

FWDCG

MIDCG

MIDCG

MIDCG

AFTCG

AFTCG

AFTCG

FWDCG

FWDCG

FWDCG

MIDCG

MIDCG

MIDCG

AFTCG

AFTCG

AFTCG

FWDCG

FWDCG

FWDCG

MIDCG

MIDCG

MIDCG

AFTCG

AFTCG

AFTCG

FWDCG

FWDCG

FWDCG

MIDCG

MIDCG

MIDCG

AFTCG

AFTCG

AFTCG

FWDCG

FWDCG

FWDCG

MIDCG

MIDCG

MIDCG

AFTCG

AFTCG

AFTCG

FIGURE No 22

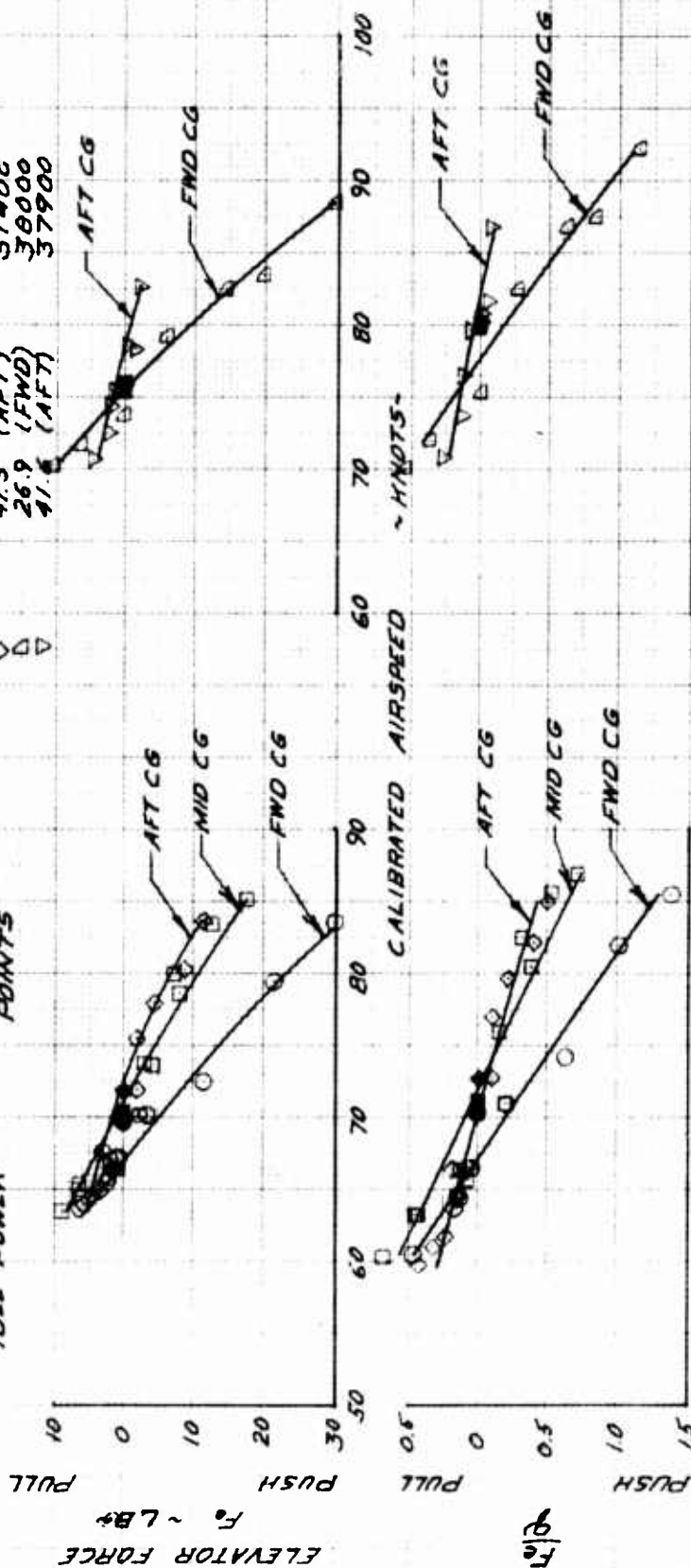
STATIC LONGITUDINAL STABILITY (STICK FREE)

CV-7A

USA S/N 63-13687

CONFIGURATION	SYMBOL	C.G. POSITION ~% MAC	AVG GROSS WT ~LB	AVG DENSITY ALT ~FT
STOL LANDING	○	27.5 (FWD)	30900	7500
FLAPS 40 DEG	◻	34.1 (MID)	30800	7500
IDLE POWER	△	41.5 (AFT)	31400	7500
	◊	26.9 (FWD)	30000	7500
	▽	41.6 (AFT)	37900	7500

NOTE
SHADED SYMBOLS
DENOTE TRIM
POINTS



LIFT COEFFICIENT $\sim C_L$

GEAR DOWN CG LIMITS
26.5% MAC FWD
41.5% MAC AFT

$N' = 52.5\% \text{ MAC}$

CENTER OF GRAVITY POSITION ~% MAC

FIGURE NO 23
MANEUVERING FLIGHT CHARACTERISTICS
CV-7A **USA S/N 63-13687**

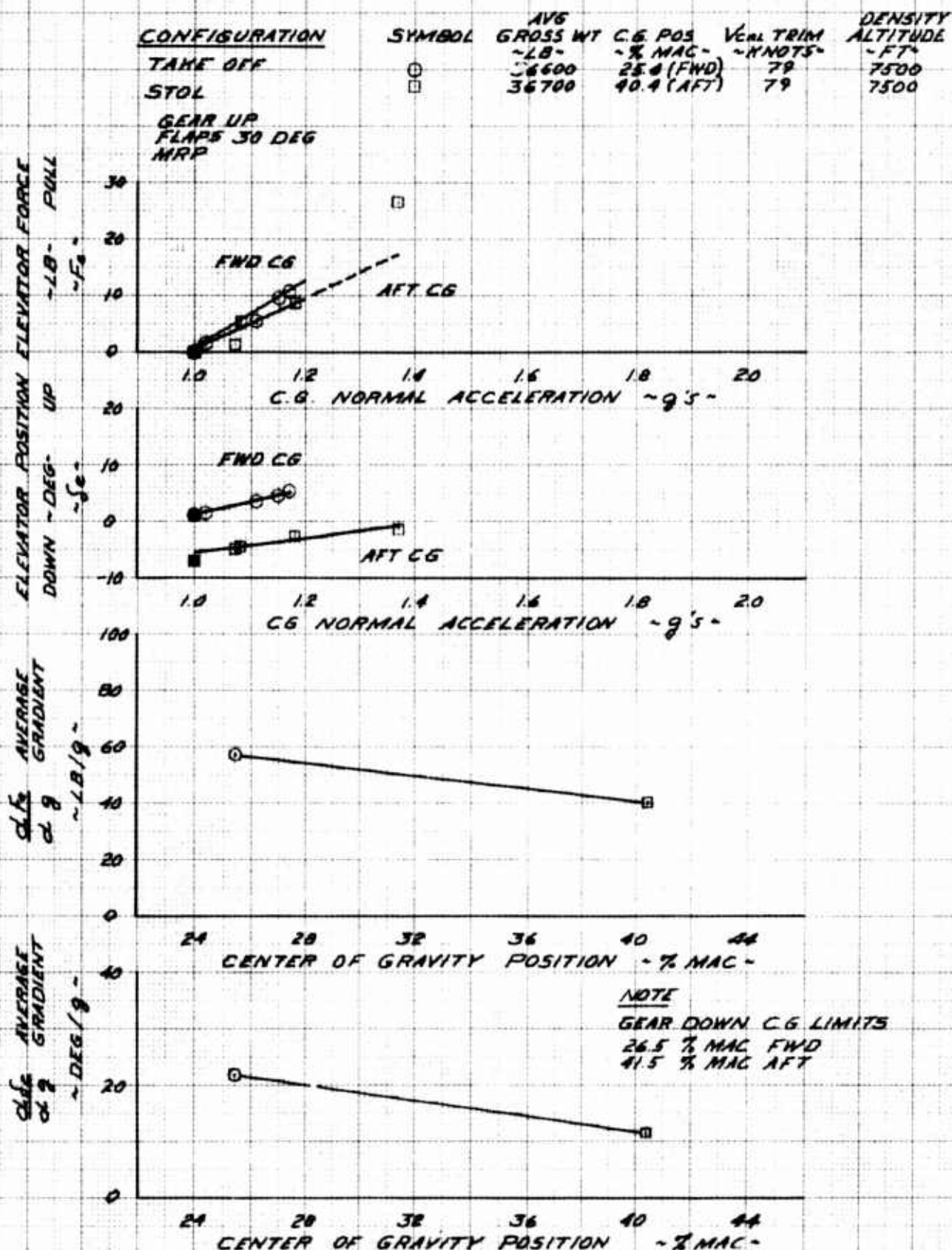


FIGURE No 24
MANEUVERING FLIGHT CHARACTERISTICS
CV-7A USA S/n 63-13687

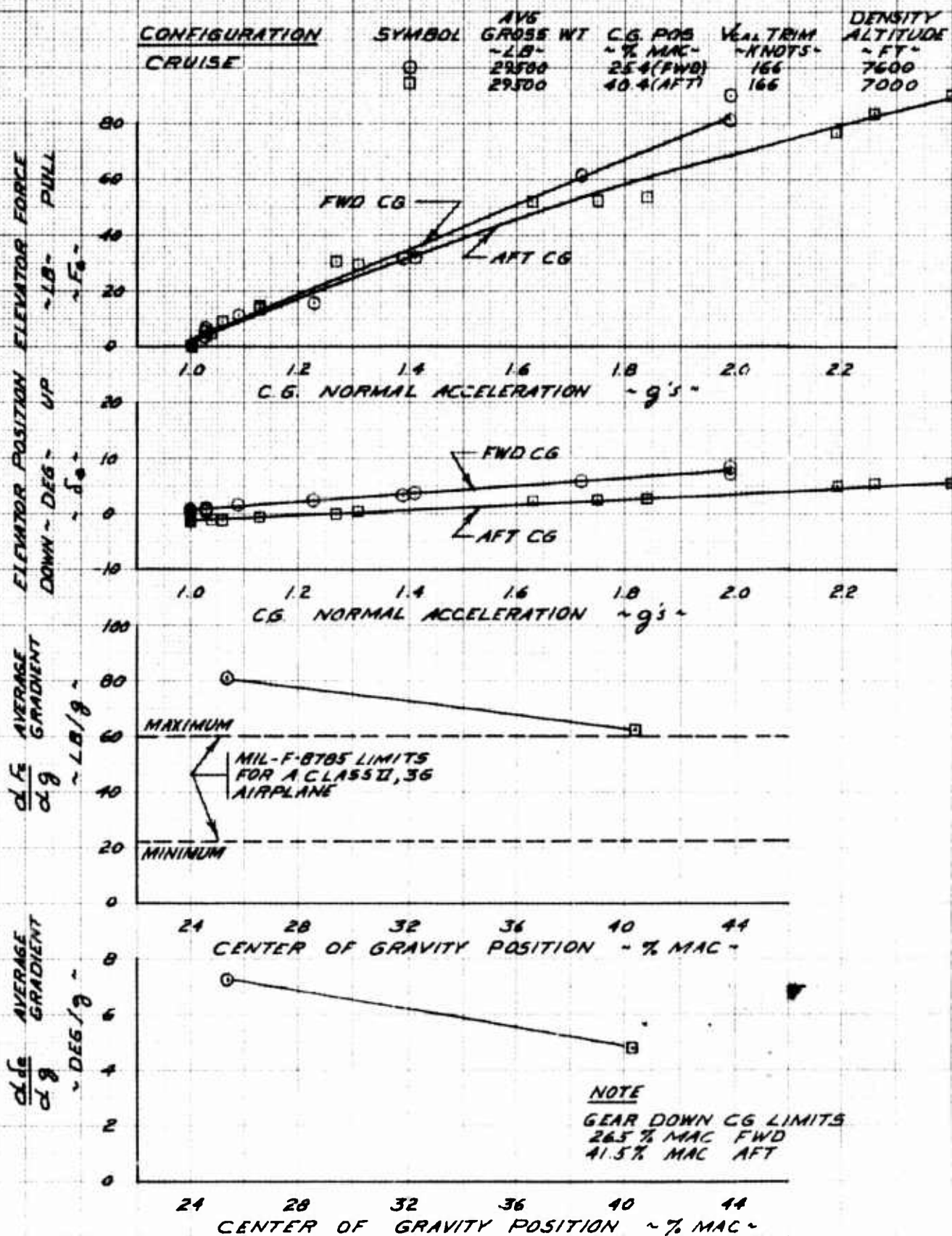


FIGURE No 25
MANEUVERING FLIGHT CHARACTERISTICS
CV-7A **USA S/N 63-13687**

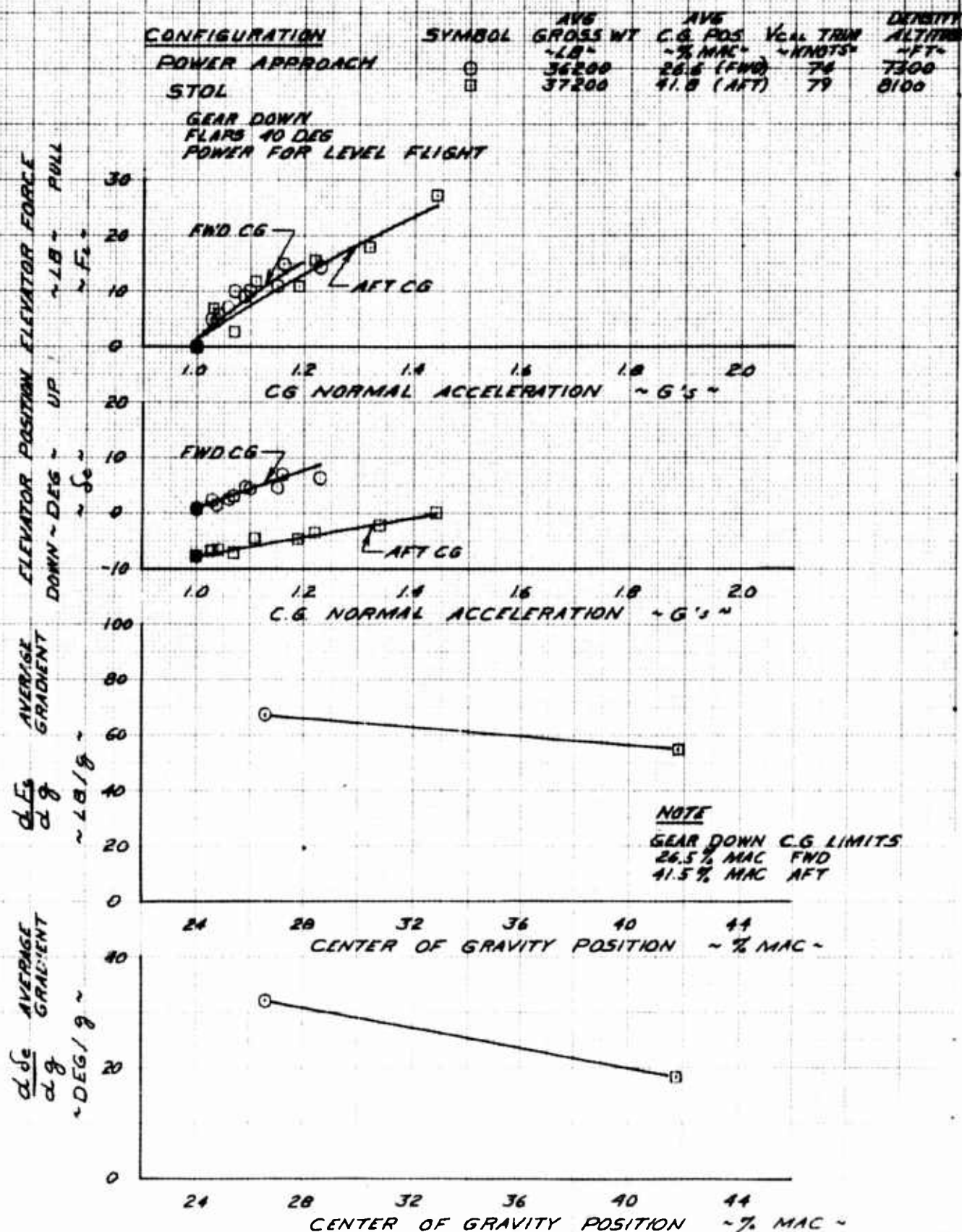


FIGURE NO 26
MANEUVERING FLIGHT CHARACTERISTICS
CV-7A USA S/N 63-13687

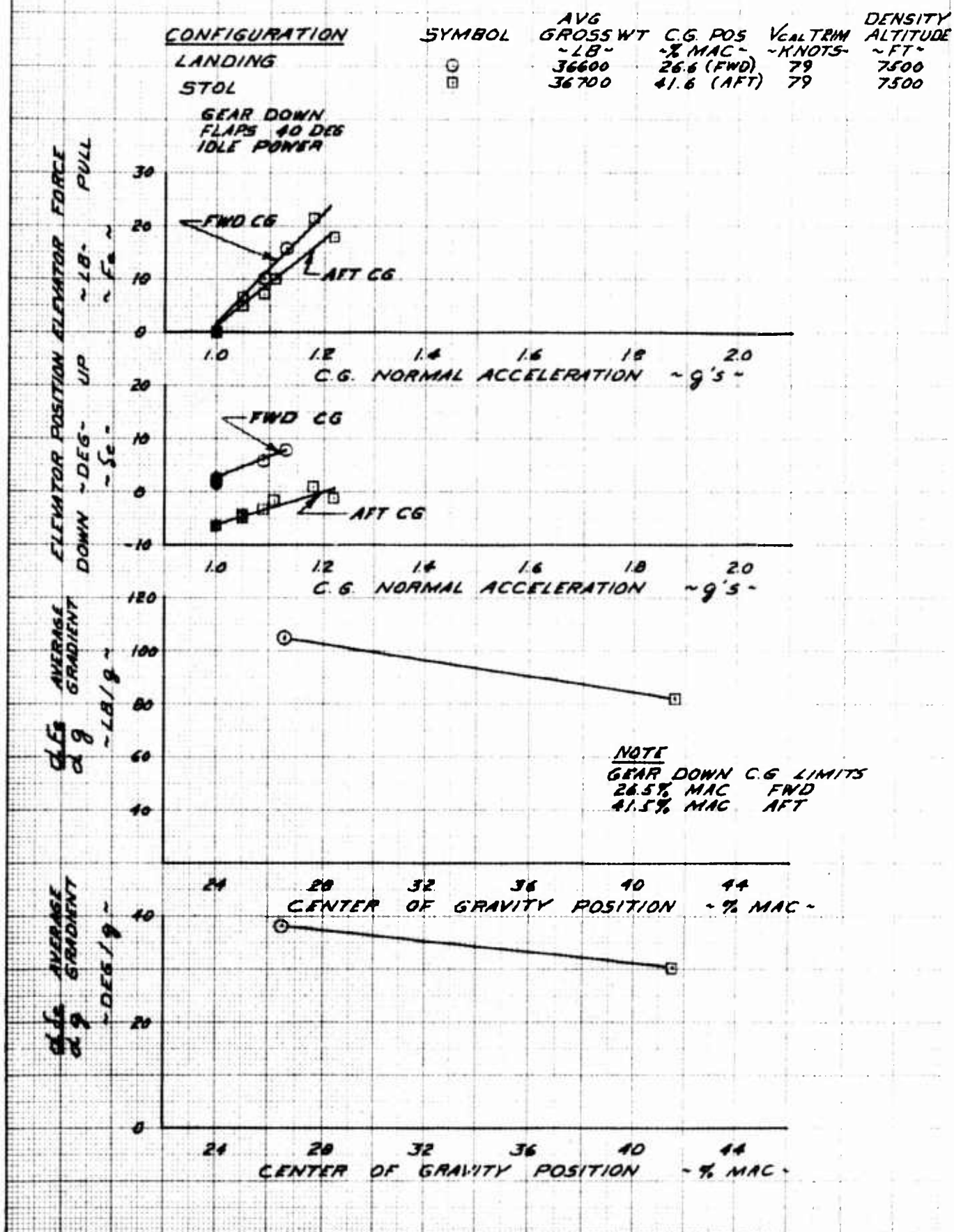


FIGURE No 27
STATIC LATERAL - DIRECTIONAL STABILITY
CV-7A USA S/N 63-13687

CONFIGURATION

CLIMB

NORMAL RATED POWER

CALIBRATED AIRSPEED 409 KTS

DENSITY ALTITUDE ~ 7500 FT

GROSS WEIGHT ~ 30500 LB

C.G. POSITION ~ 27.4% MAC (FWD)

CONTROL SURFACE POSITIONS ~ DEG ~	NOSE DWN	○	ELEVATOR POSITION UP	UP	PUSH	○	ELEVATOR FORCE	PULL
	LEFT ROLL	□	AILERON POSITION RT	RT	LEFT	□	AILERON FORCE	RIGHT
	LEFT YAW	◇	RUDDER POSITION RT	RT				
AIRCRAFT ATTITUDE ~ DEG FROM TRIM ~								
	DWN	○	PITCH	UP				
	LT	□	ROLL	RT				

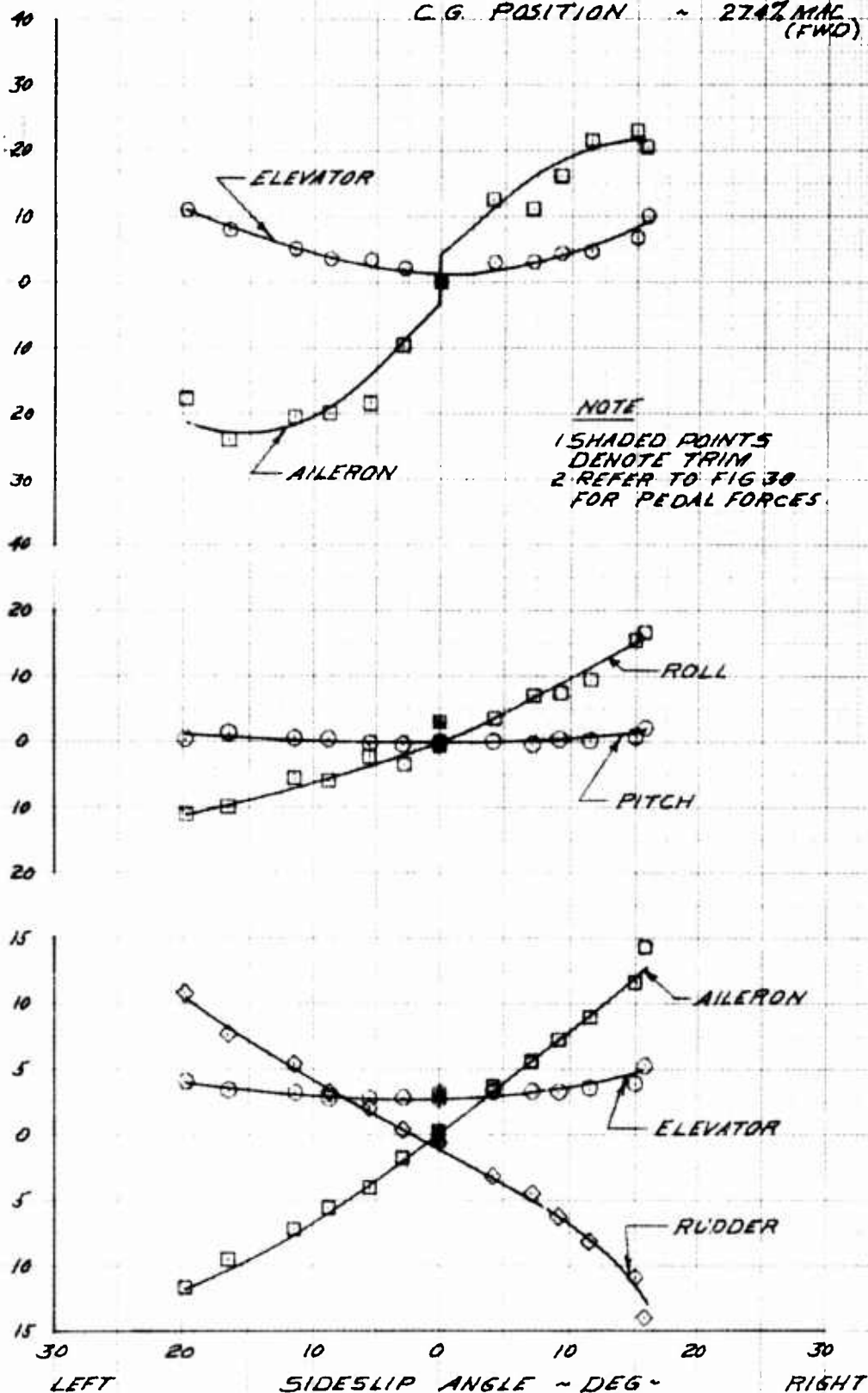


FIGURE No 28
STATIC LATERAL-DIRECTIONAL STABILITY
CV-7A (ISA SIN 63-13687)

CONFIGURATION

CRUISE

POWER FOR LEVEL FLIGHT

CALIBRATED AIRSPEED ~ 146 KTS

DENSITY ALTITUDE ~ 7200 FT

GROSS WEIGHT ~ 36900 LB

C.G. POSITION ~ 26.6% MAC (END)

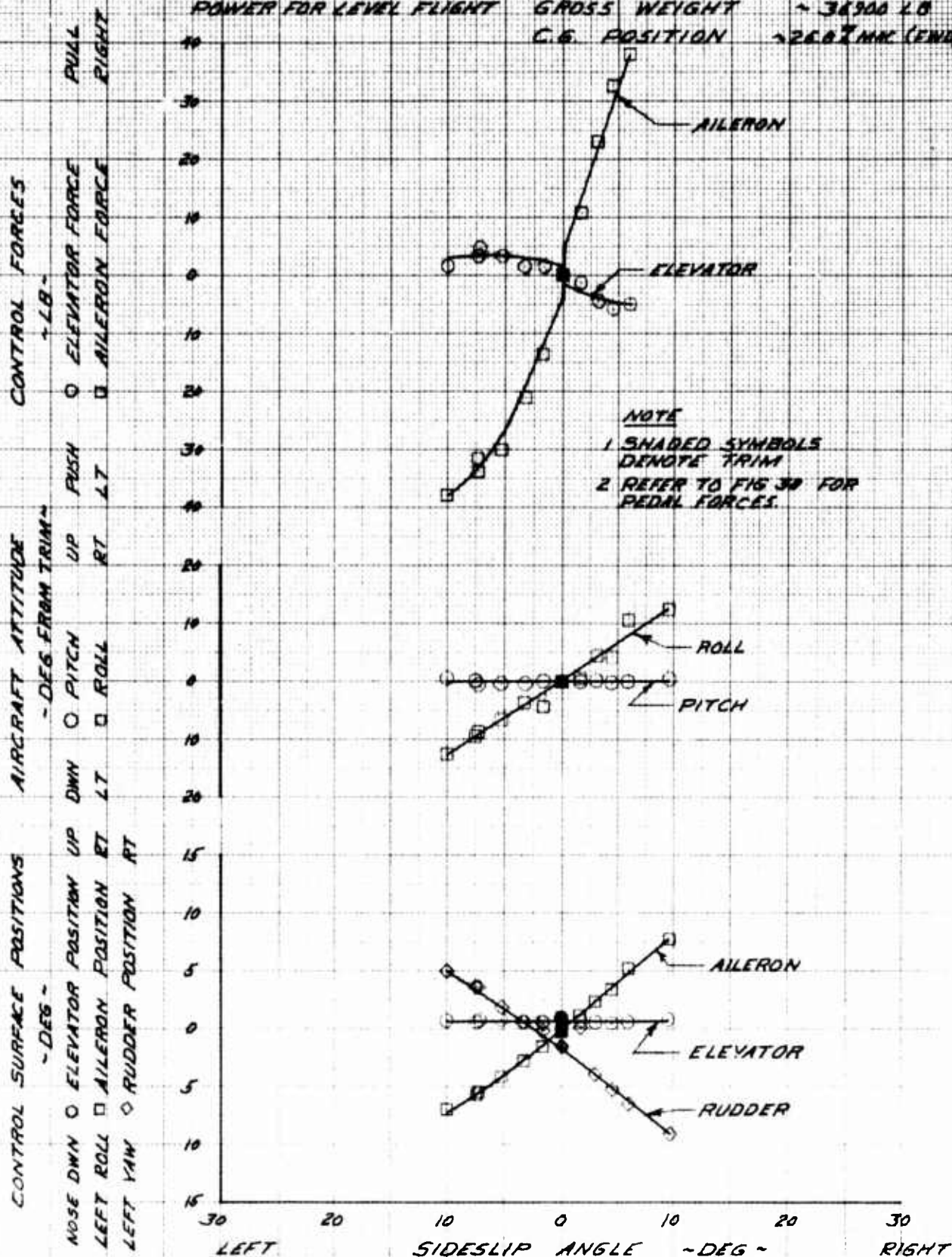


FIGURE No 29
STATIC LATERAL-DIRECTIONAL STABILITY
CV-7A **USA S/N 63-13687**

CONFIGURATION

POWER APPROACH

STOL - FLAPS 40 DEG - GEAR DOWN
POWER FOR LEVEL FLIGHT

CALIBRATED AIRSPEED ~ 67 KTS

DENSITY ALTITUDE ~ 7600 FT

GROSS WEIGHT ~ 30000 LB

C.G. POSITION ~ 41.5% MAC (MFT)

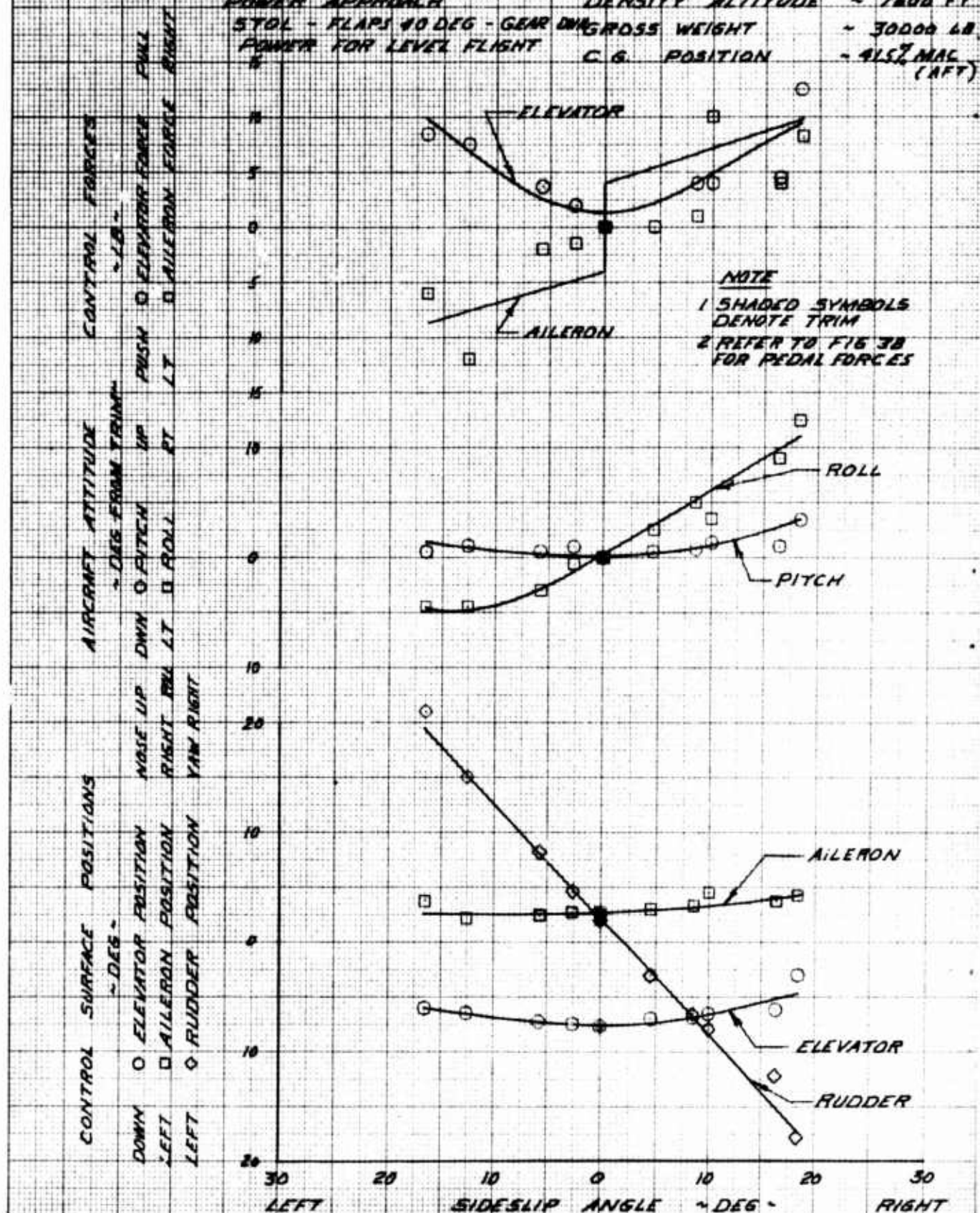


FIGURE No 30
STATIC LATERAL - DIRECTIONAL STABILITY
CV-7A **USA S/N 63-13687**

<u>CONFIGURATION</u>	<u>CALIBRATED AIRSPEED</u>	~ 71 KTS
LANDING	<u>DENSITY ALTITUDE</u>	~ 7500 FT
STOL - FLAPS 40° - GEAR DOWN	<u>GROSS WEIGHT</u>	~ 30800 LB
IDLE POWER	<u>C.G. POSITION</u>	~ 41.5% MAC (REF)

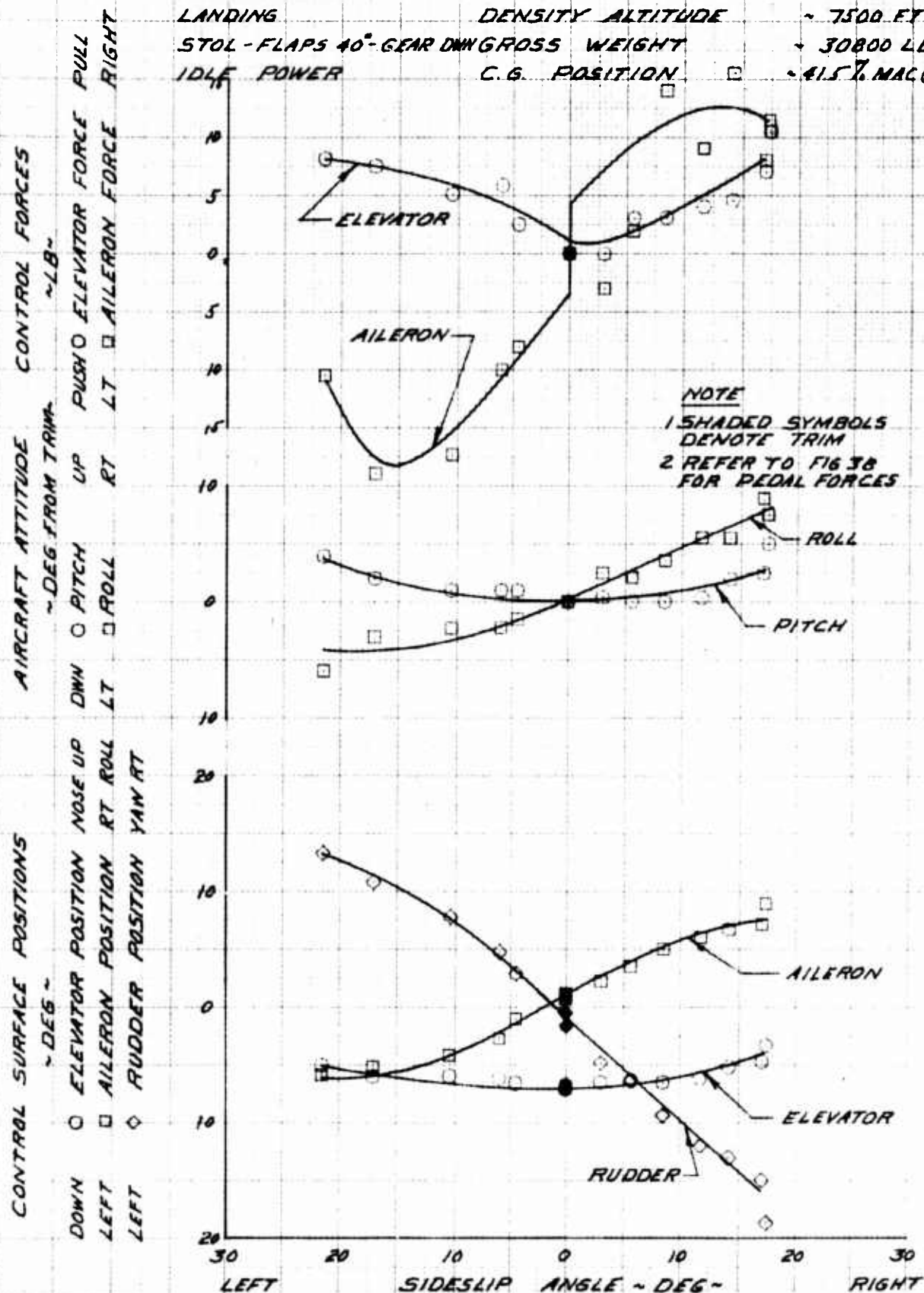


FIGURE NO 31
COORDINATED AILERON ROLLS
CV-7A **USA S/N 63-13687**

CONFIGURATION
 CRUISE
 MANEUVERING
 AIRSPEED

CALIBRATED AIRSPEED ~ 140 KTS
DENSITY ALTITUDE ~ 6500 FT
AVG GROSS WEIGHT ~ 36400 LB
AVG C.G. POSITION ~ 41.6% MAC (AFT)

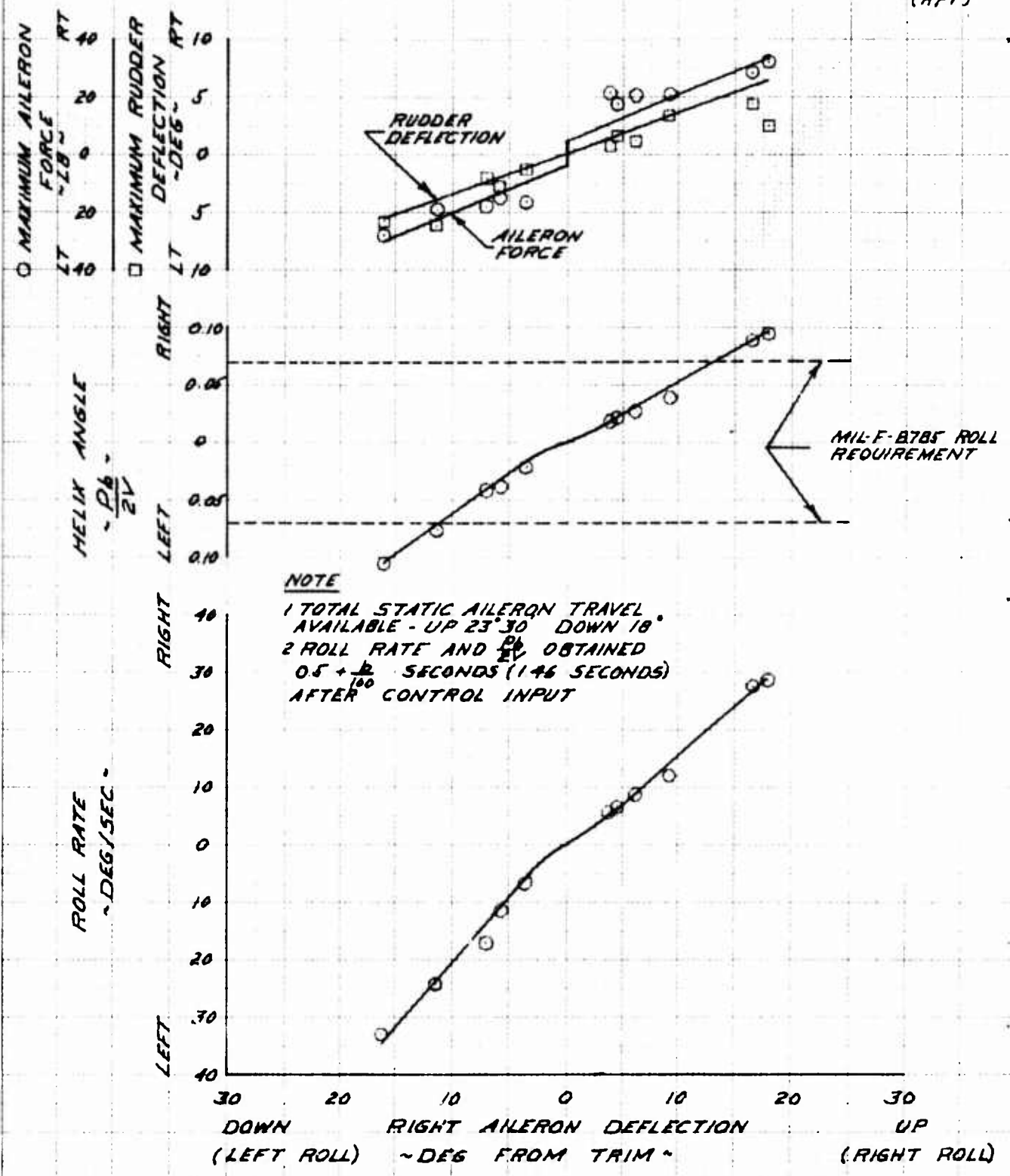


FIGURE NO 32
COORDINATED AILERON ROLLS
CV-7A USA S/N 63-13687

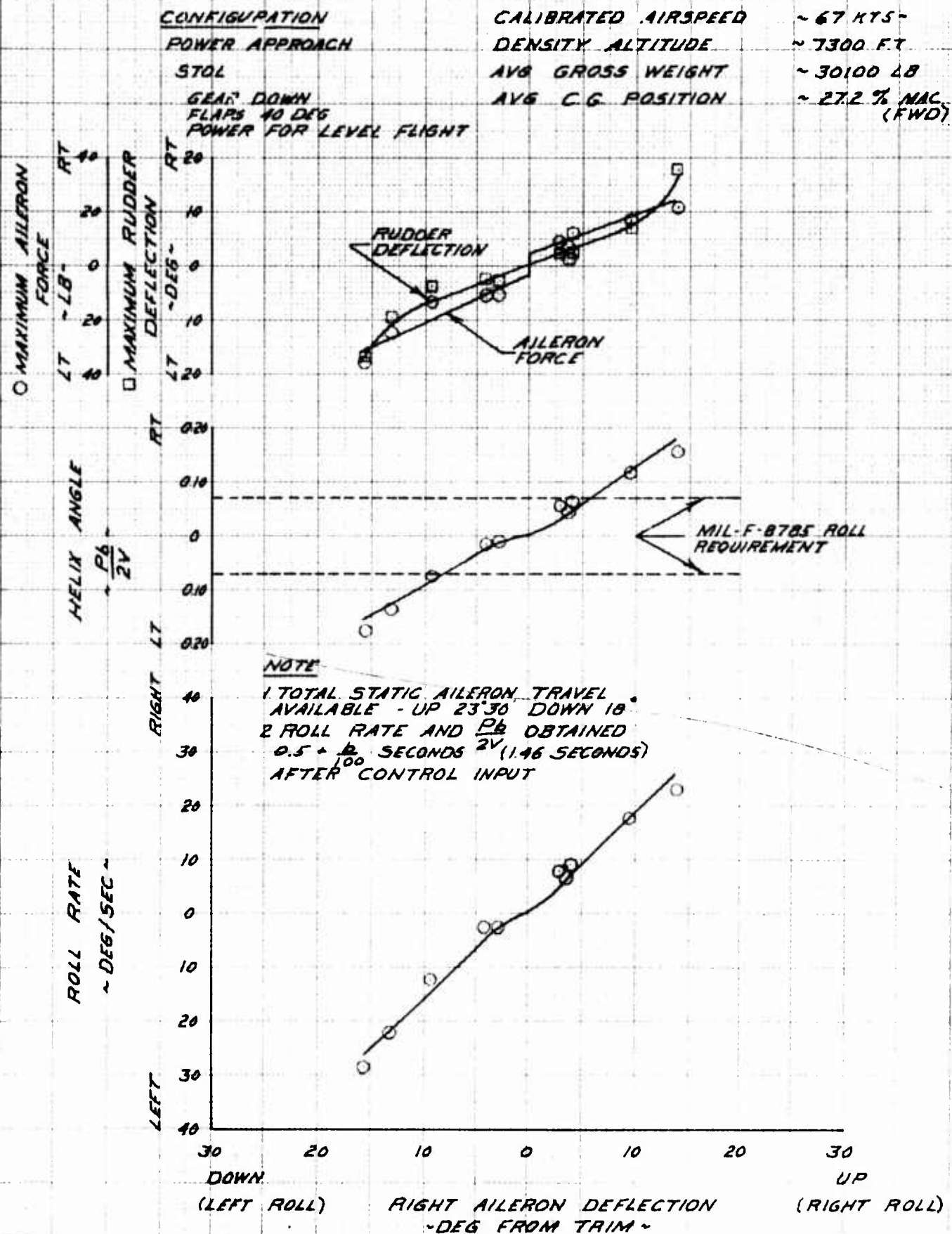


FIGURE NO 33
COORDINATED AILERON ROLLS
 CV-7A USA S/N 63-13687

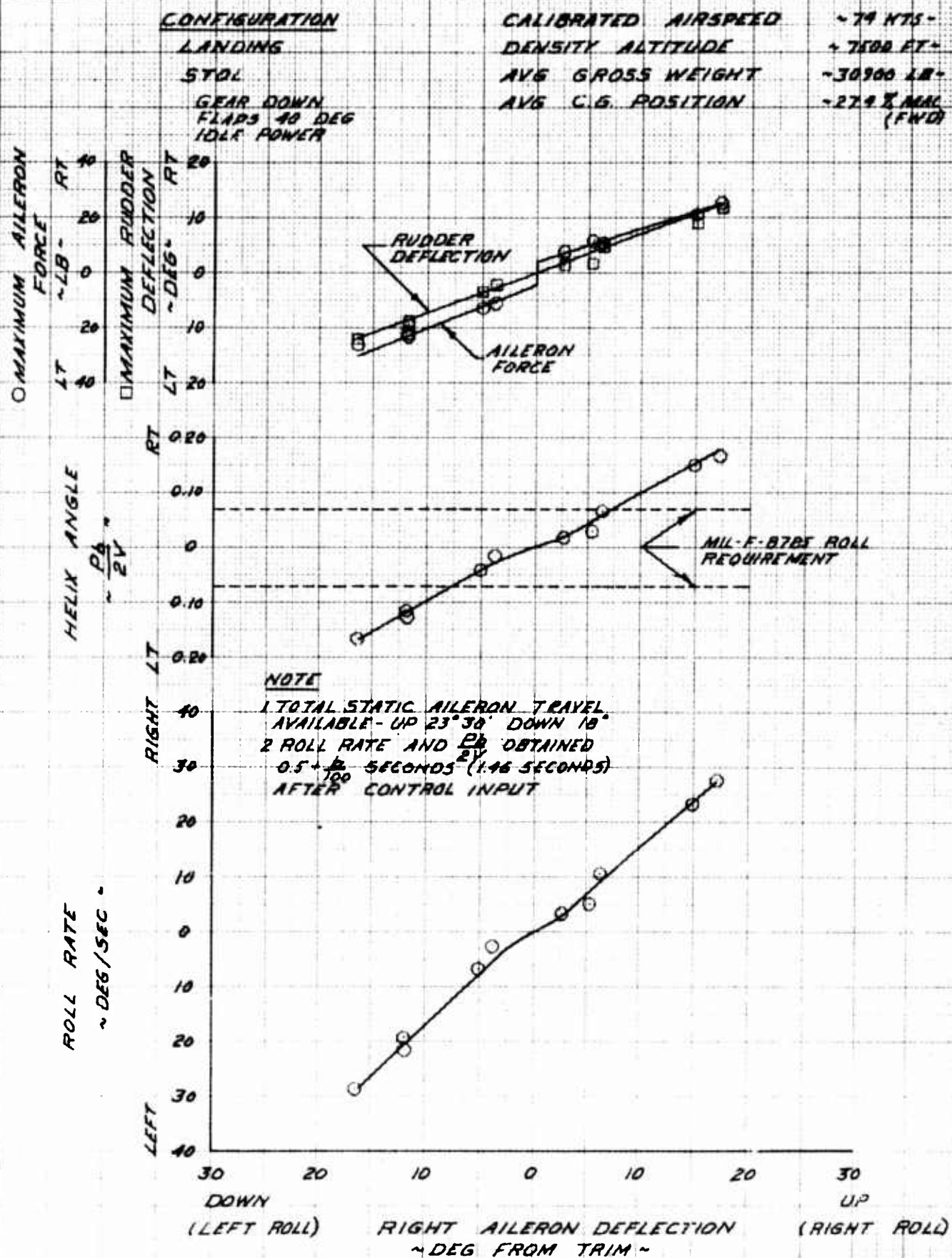


FIGURE NO 34
 COORDINATED AILERON ROLL
 CV-7A USA S/N 63-13687
 STOL LANDING CONFIGURATION

DENSITY ALTITUDE - 7000 FT GROSS WEIGHT - 30500 LB
 CALIBRATED AIRSPEED - 71 KNOTS C.G. POSITION - 27.1% MAC

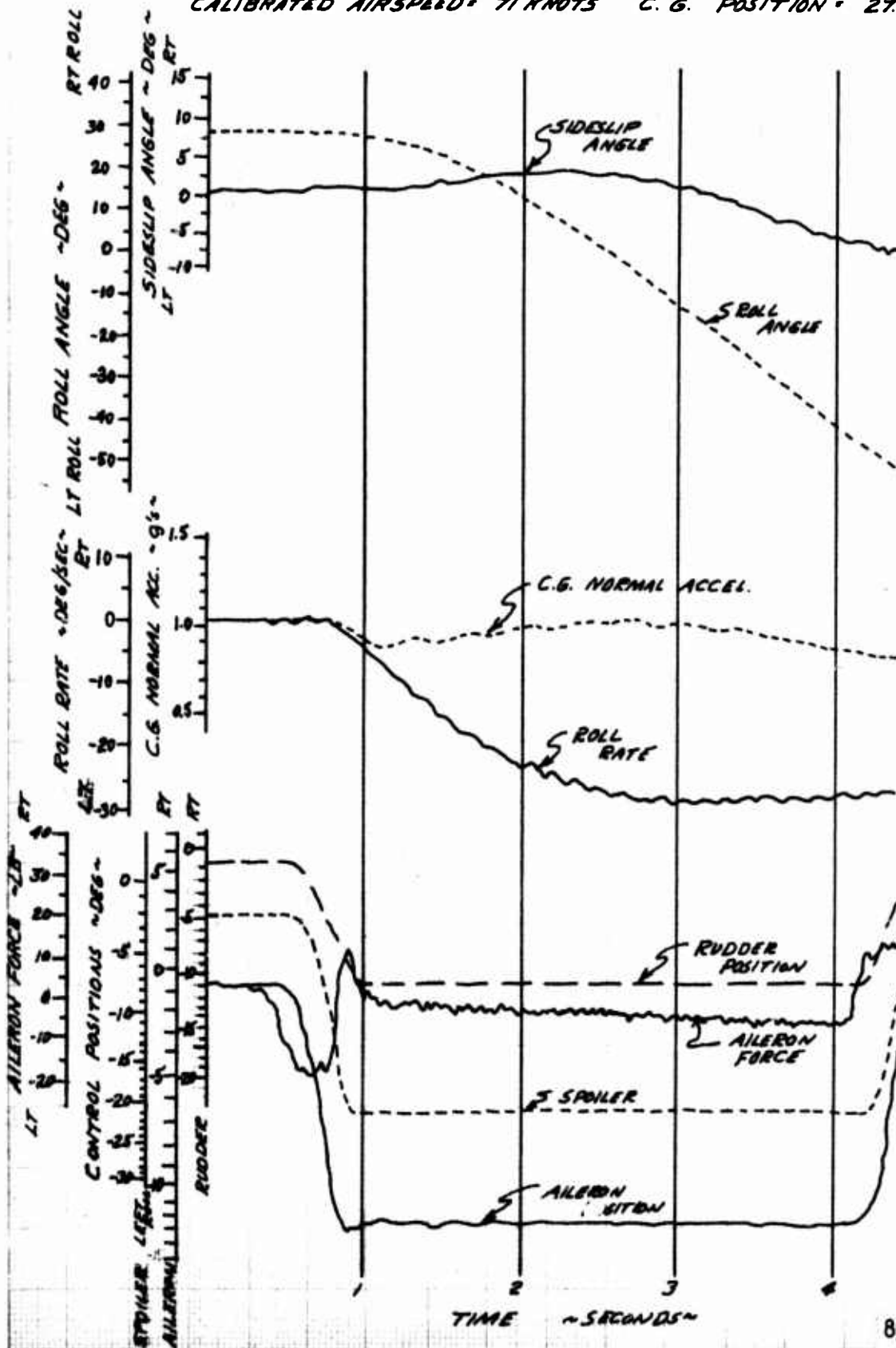


FIGURE NO 35
 COORDINATED AILERON ROLL
 CV-7A USA S/N 63-13687
 STOL LANDING CONFIGURATION

DENSITY ALTITUDE - 7500 FT GROSS WEIGHT - 30500 LB
 CALIBRATED AIRSPEED - 73 KNOTS C.G. POSITION - 27.2% MAC (FWD)

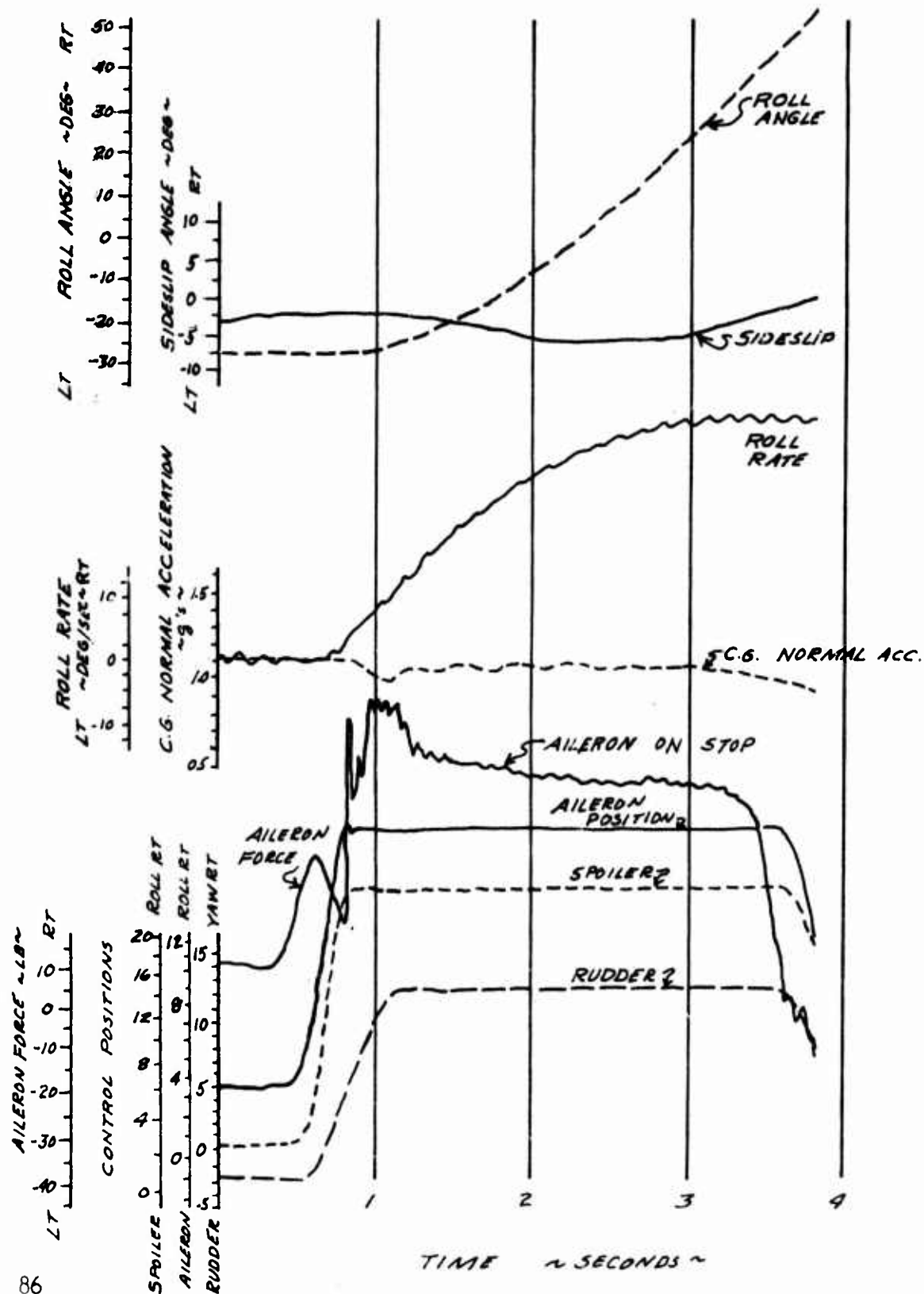


FIGURE NO 36
PEDAL FIXED AILERON ROLLS
CV-7A **USA S/N 63-13687**

CONFIGURATION
POWER APPROACH
STOL

GEAR DOWN
FLAPS 10 DEG
POWER FOR LEVEL FLIGHT

CALIBRATED AIRSPEED ~ 74 KTS
DENSITY ALTITUDE ~ 7300 FT
AVG GROSS WEIGHT ~ 37400 LB
AVG CG POSITION ~ 26.8% MAC (FWD)

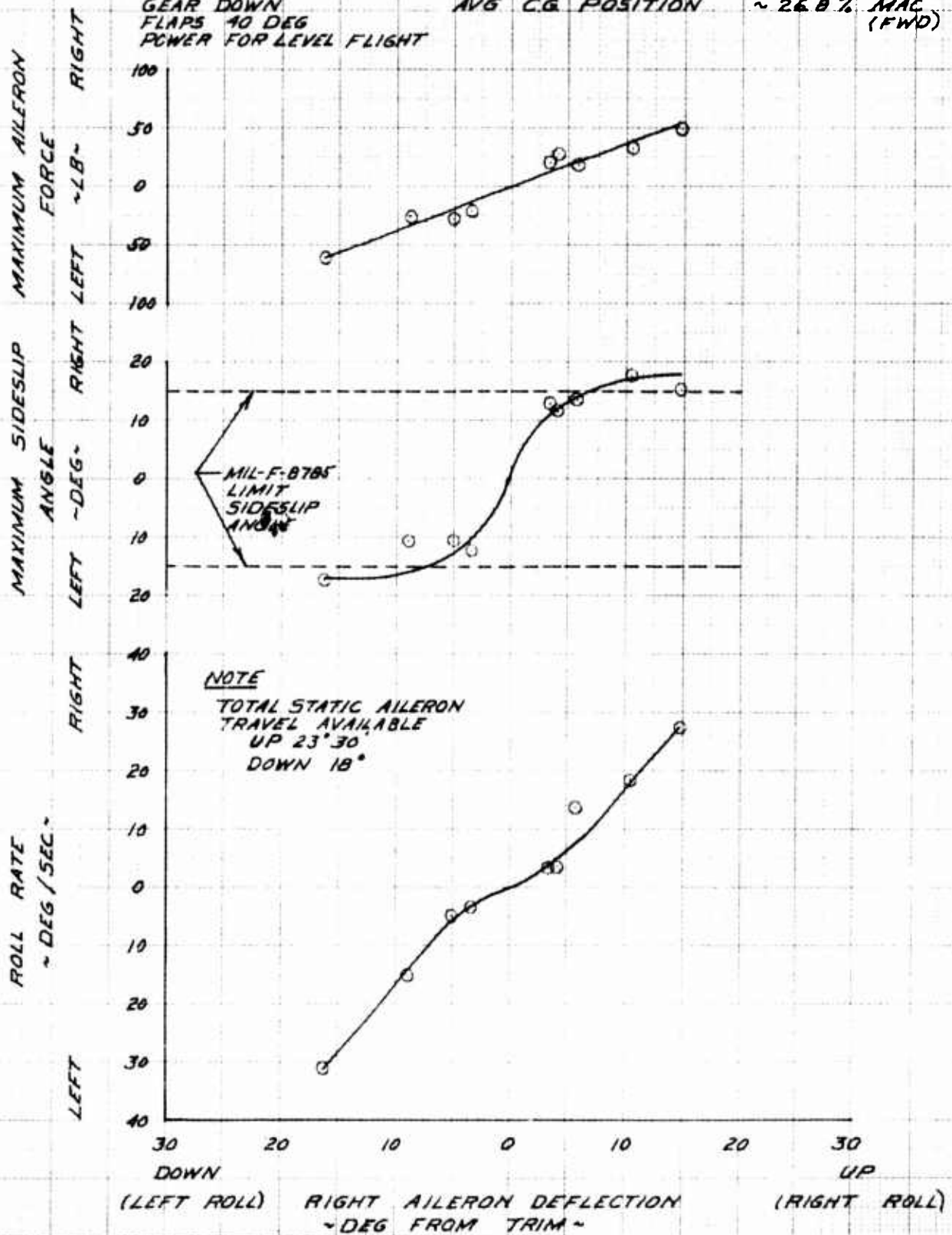


FIGURE NO 37
PEDAL FIXED AILERON ROLLS
CV-7A USA S/N 63-13687

CONFIGURATION

LANDING
STOL
GEAR DOWN
FLAPS 40 DEG
IDLE POWER

CALIBRATED AIRSPEED

~ 78 KTS

DENSITY ALTITUDE

~ 8000 FT

AVG GROSS WEIGHT

~ 32000 LB

AVG C.G. POSITION

~ 26.5% MAC (FWD)

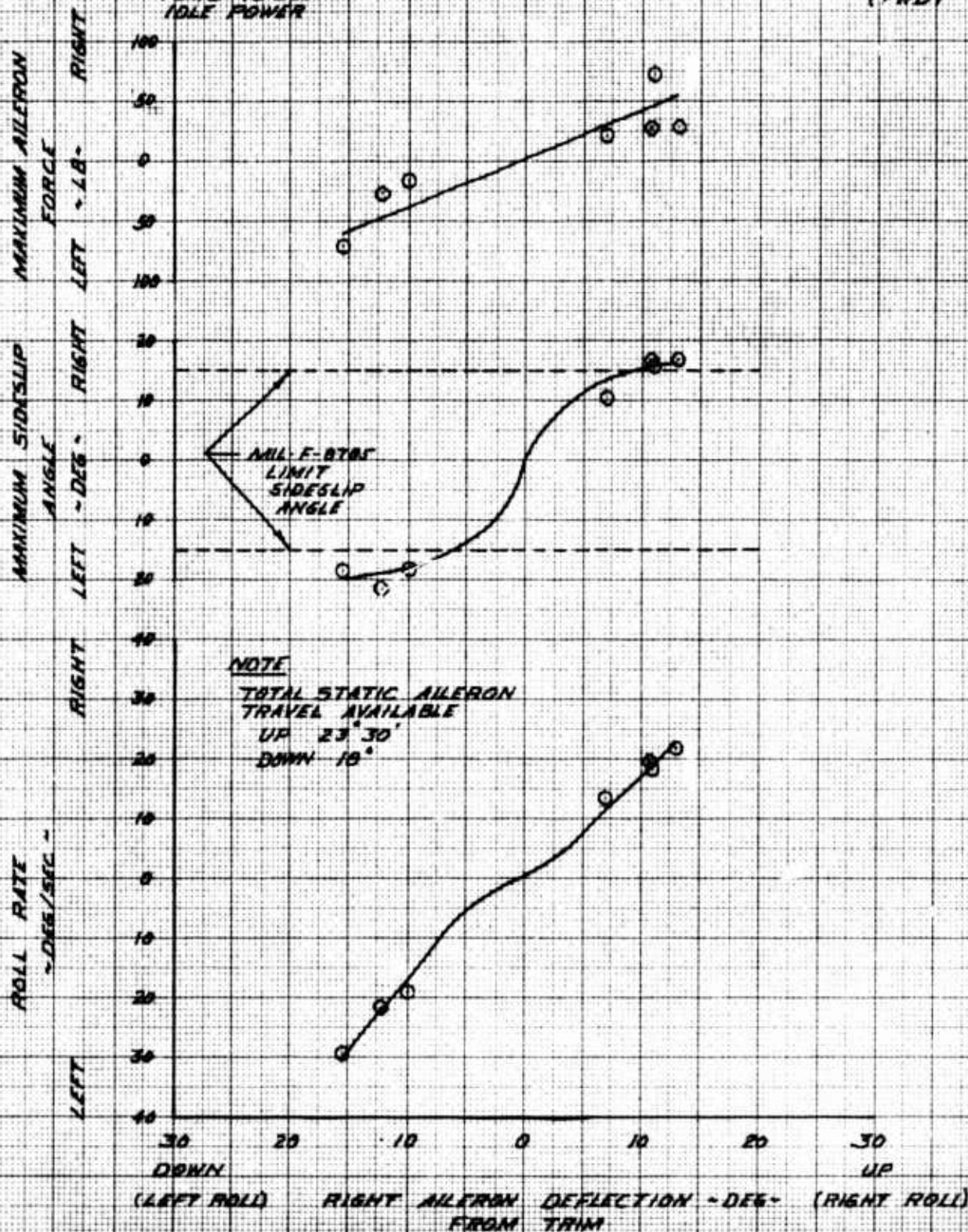


FIGURE No 38
 RUDDER PEDAL DISPLACEMENT VS PEDAL FORCE
 CV-7A USA S/N 63-13687

NOTE
 FORCES MEASURED
 STATICALLY IN
 HANGER USING
 GROUND POWER UNIT

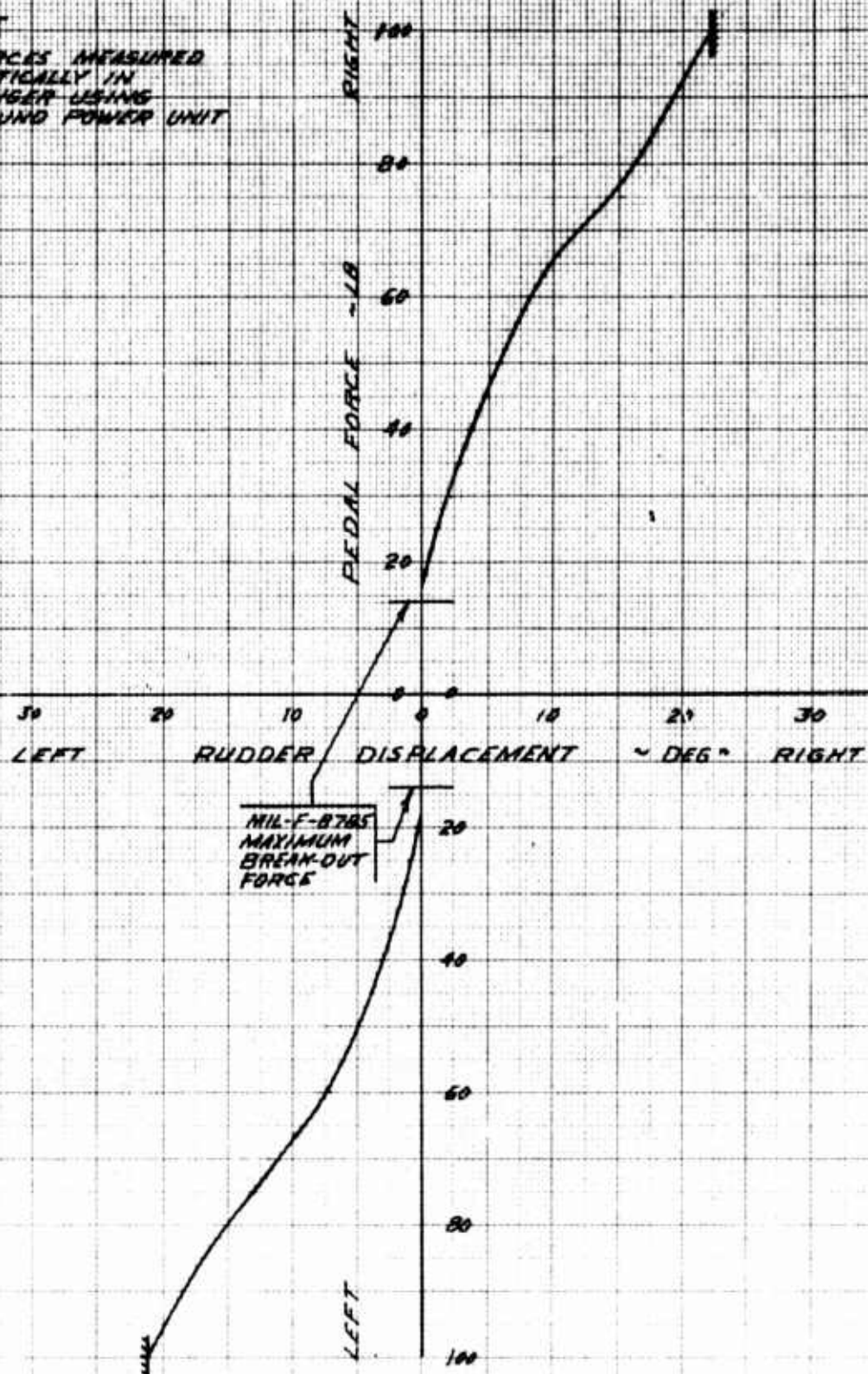
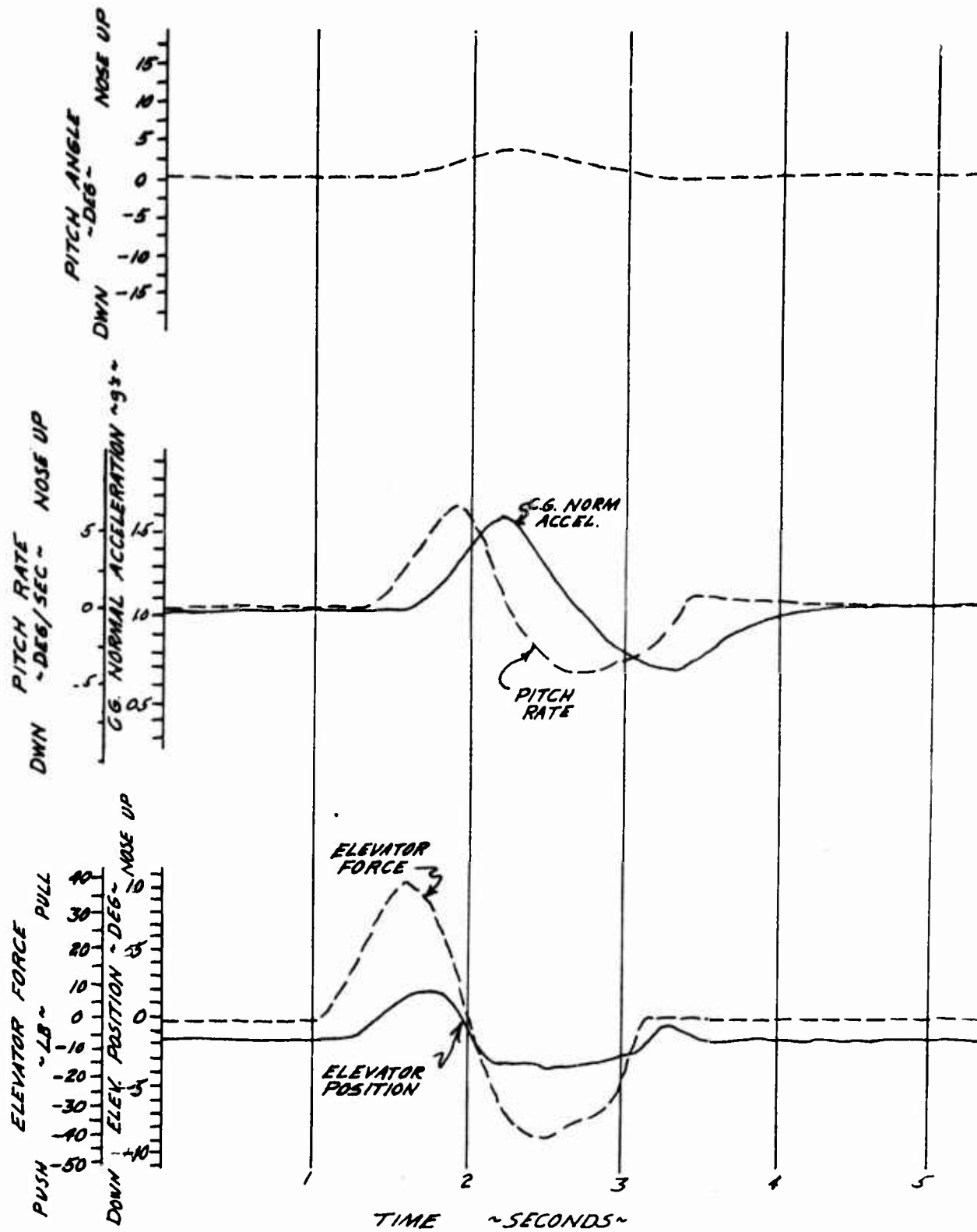


FIGURE NO 39
 LONGITUDINAL DYNAMIC STABILITY
 CV-7A USA S/N 63-13687

CRUISE CONFIGURATION

DENSITY ALTITUDE = 7500 FT GROSS WEIGHT = 31750 LB
 CALIBRATED AIRSPEED = 165 KTS C.G. POSITION = 41.5% MAC



(AFT)

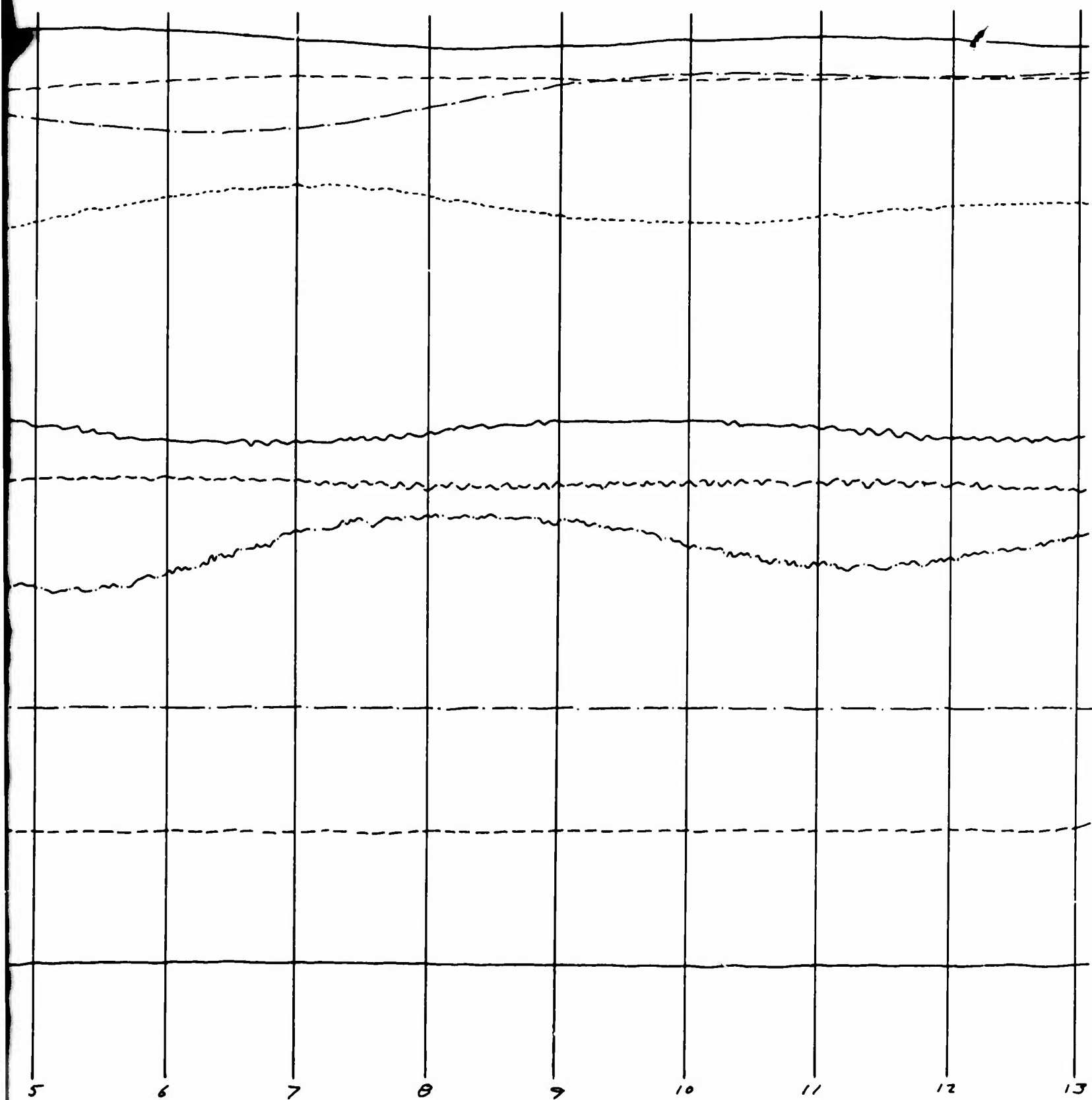


FIGURE NO. 40

RELEASE FROM SIDESLIP
CV-7A USA S/N 63-13607

STOL LANDING CONFIGURATION

DENSITY ALTITUDE = 7300 FT GROSS WT = 31500 LB
AIRSPEED (TRIM) = 67 KNOTS CAS C.G. POSITION = 41.1% MAC (AFT)

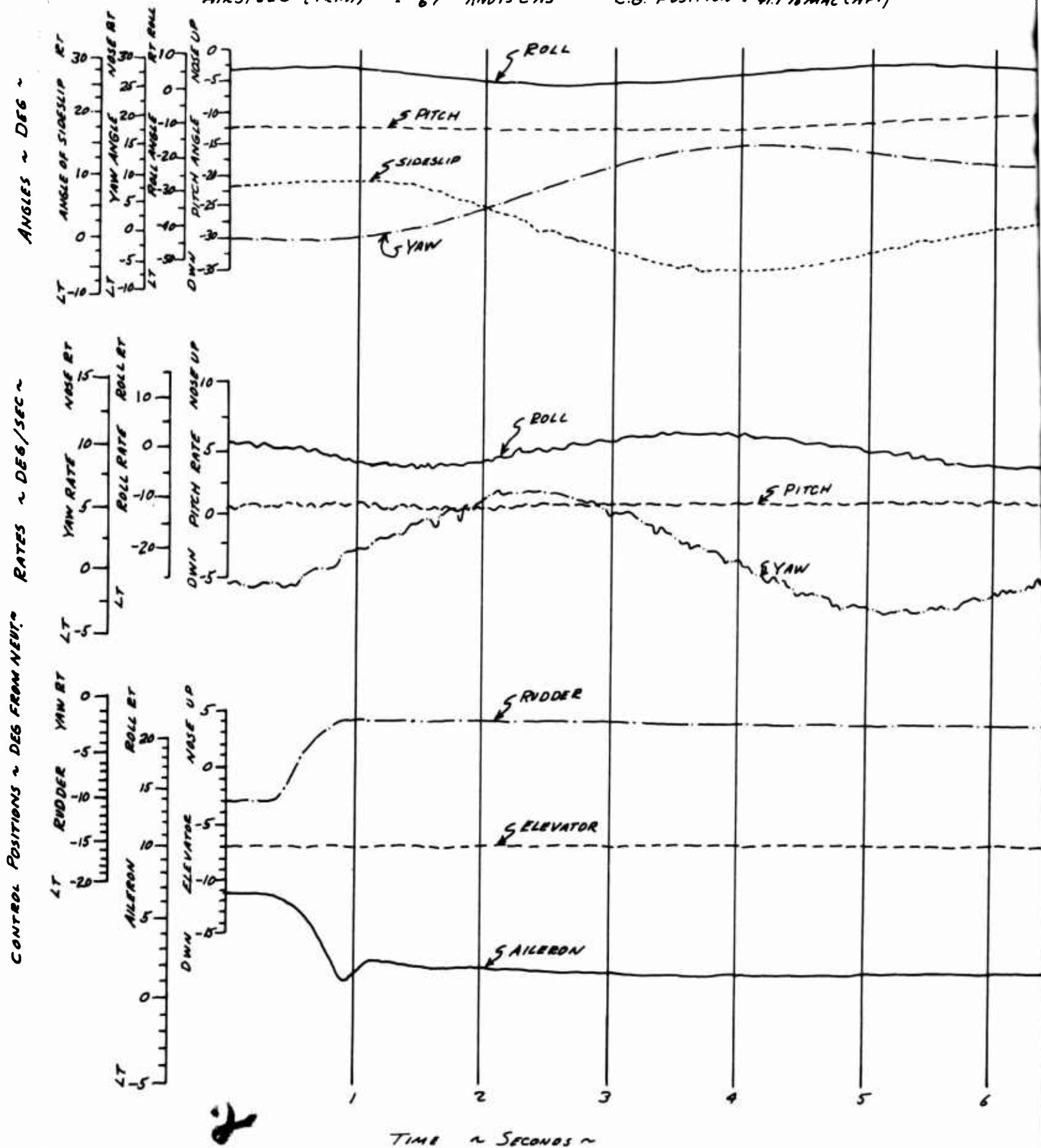


FIGURE NO 41
RELEASE FROM SIDESLIP

CV-7A USA S/N 63-13687

CRUISE CONFIGURATION

DENSITY ALTITUDE - 7500 FT
CALIBRATED AIRSPEED - 166 KTS

GROSS WEIGHT - 31 700 LB
C.G. POSITION - 41.5% MAC (AFT)

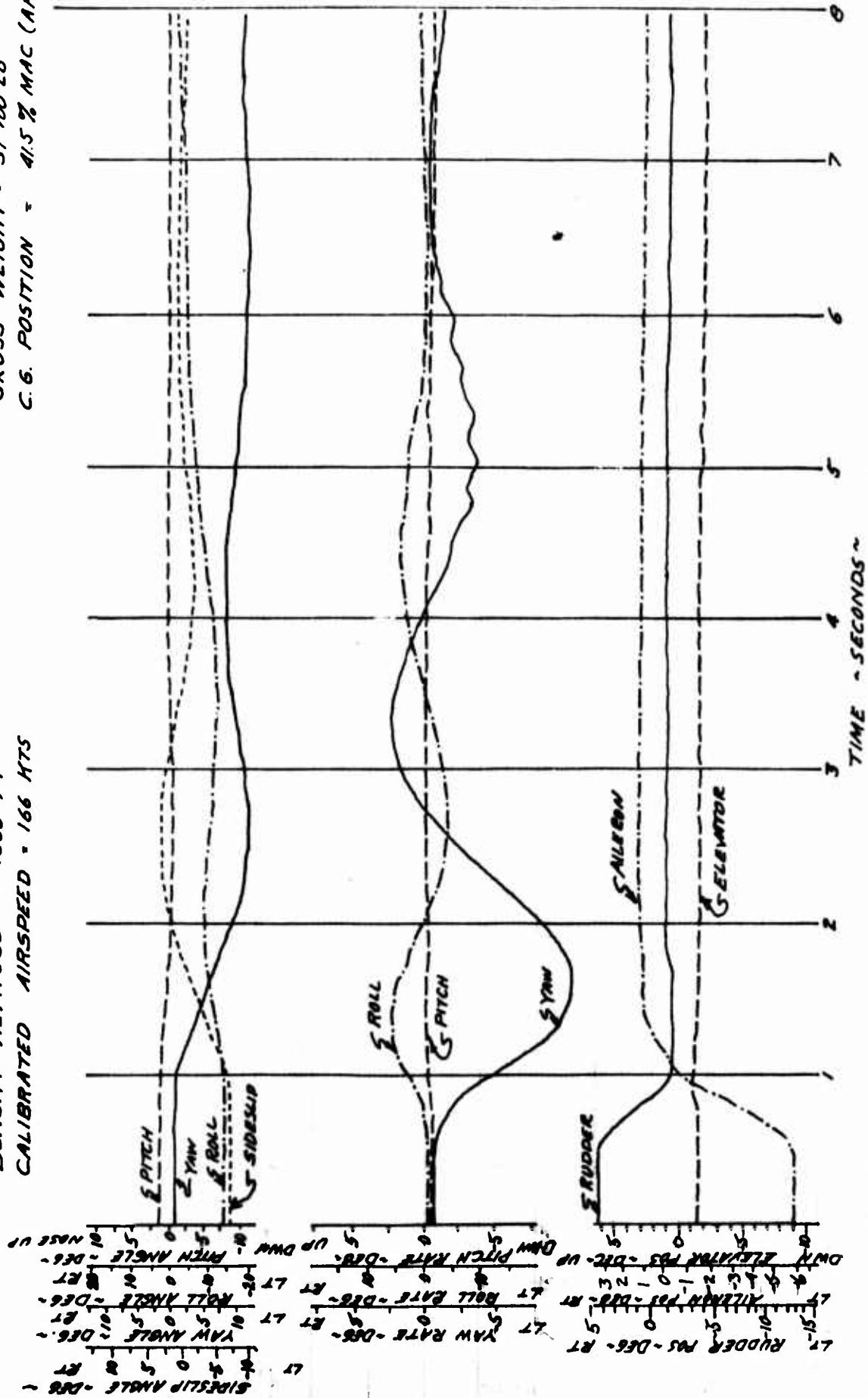


FIGURE NO 42
STOL TAKE-OFF ENGINE FAILURE
CV-7A USA S/N 63-13687

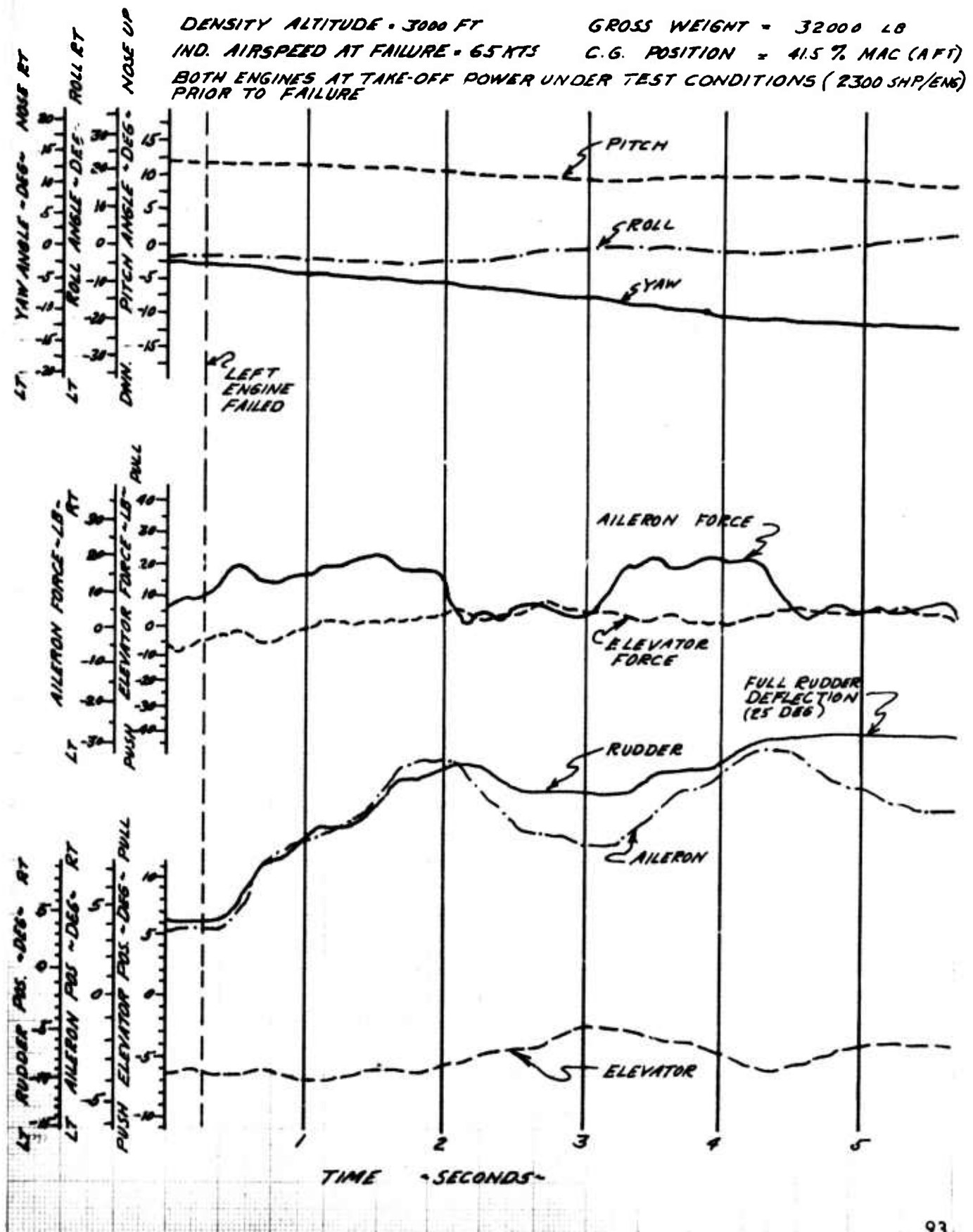


FIGURE NO 43
STOL STALL CHARACTERISTICS
CV-7A USA S/N 63-13687
STOL LANDING CONFIGURATION

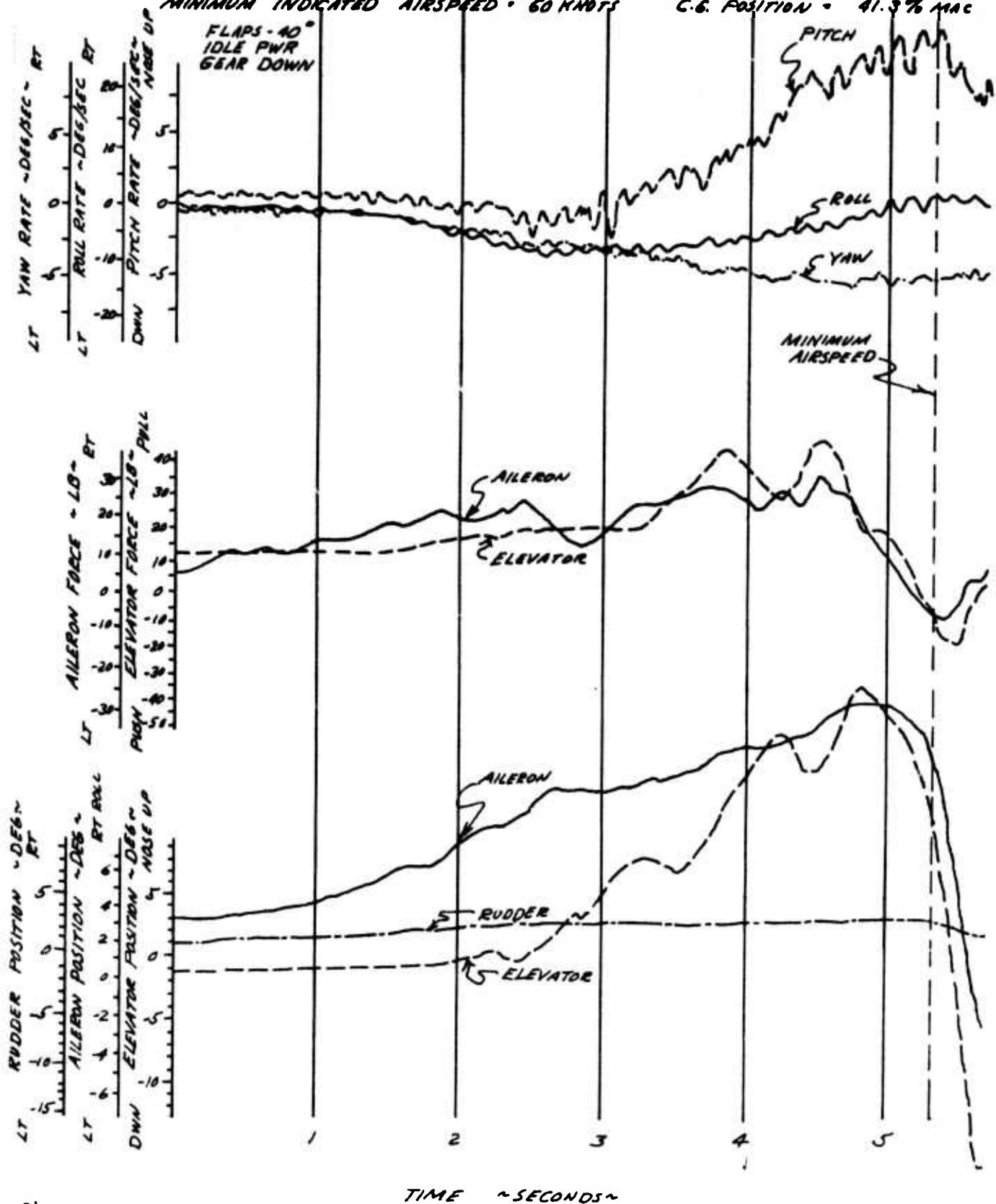
DENSITY ALTITUDE - 8000 FT

GROSS WEIGHT - 30000 LB

MINIMUM INDICATED AIRSPEED - 60 KNOTS

C.G. POSITION - 41.3% MAC

FLAPS - 40°
IDLE PWR
GEAR DOWN



POSITION: 41.5% MAC (AFF)

STALL (50.5 KNOTS IAS)

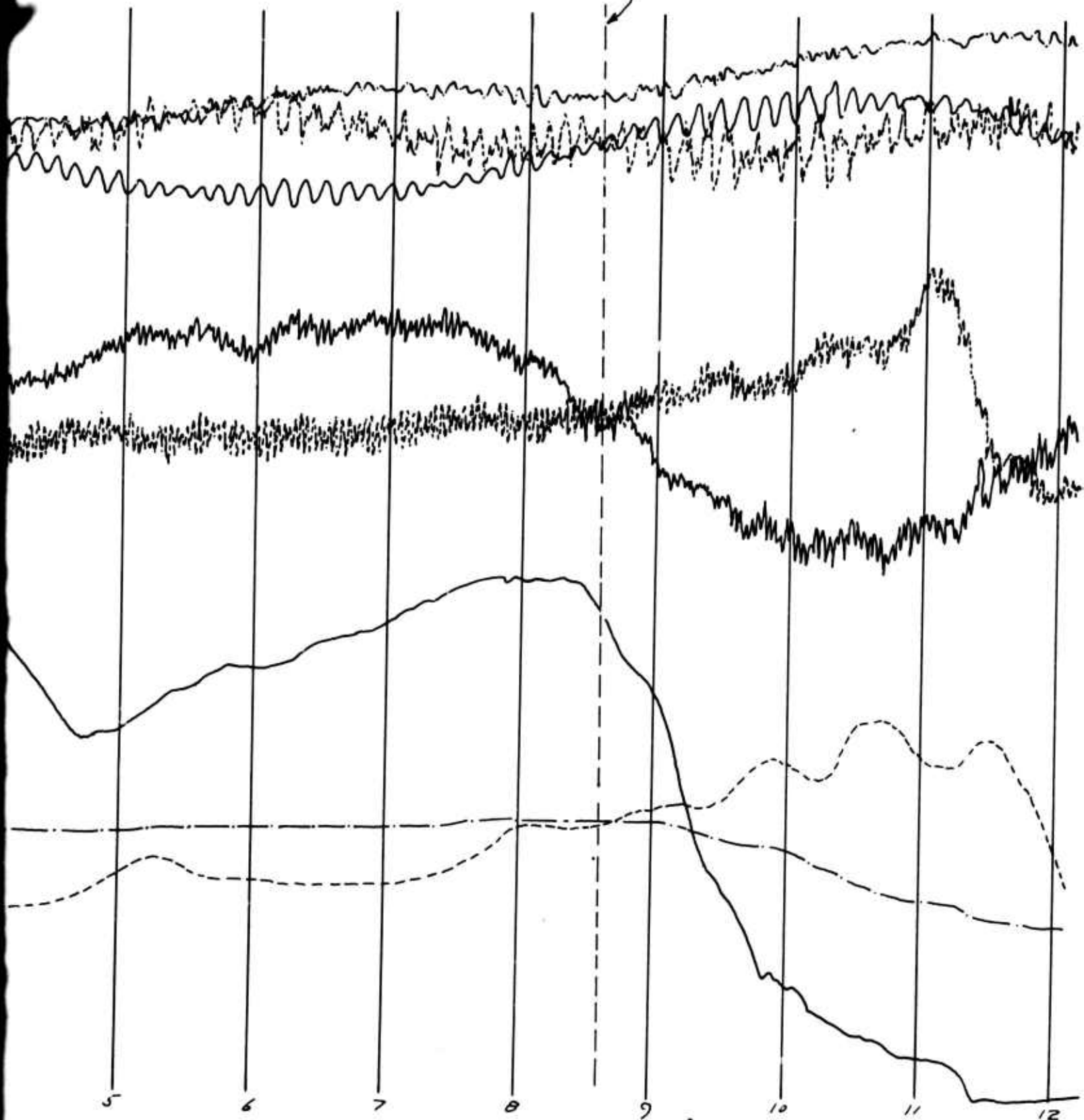


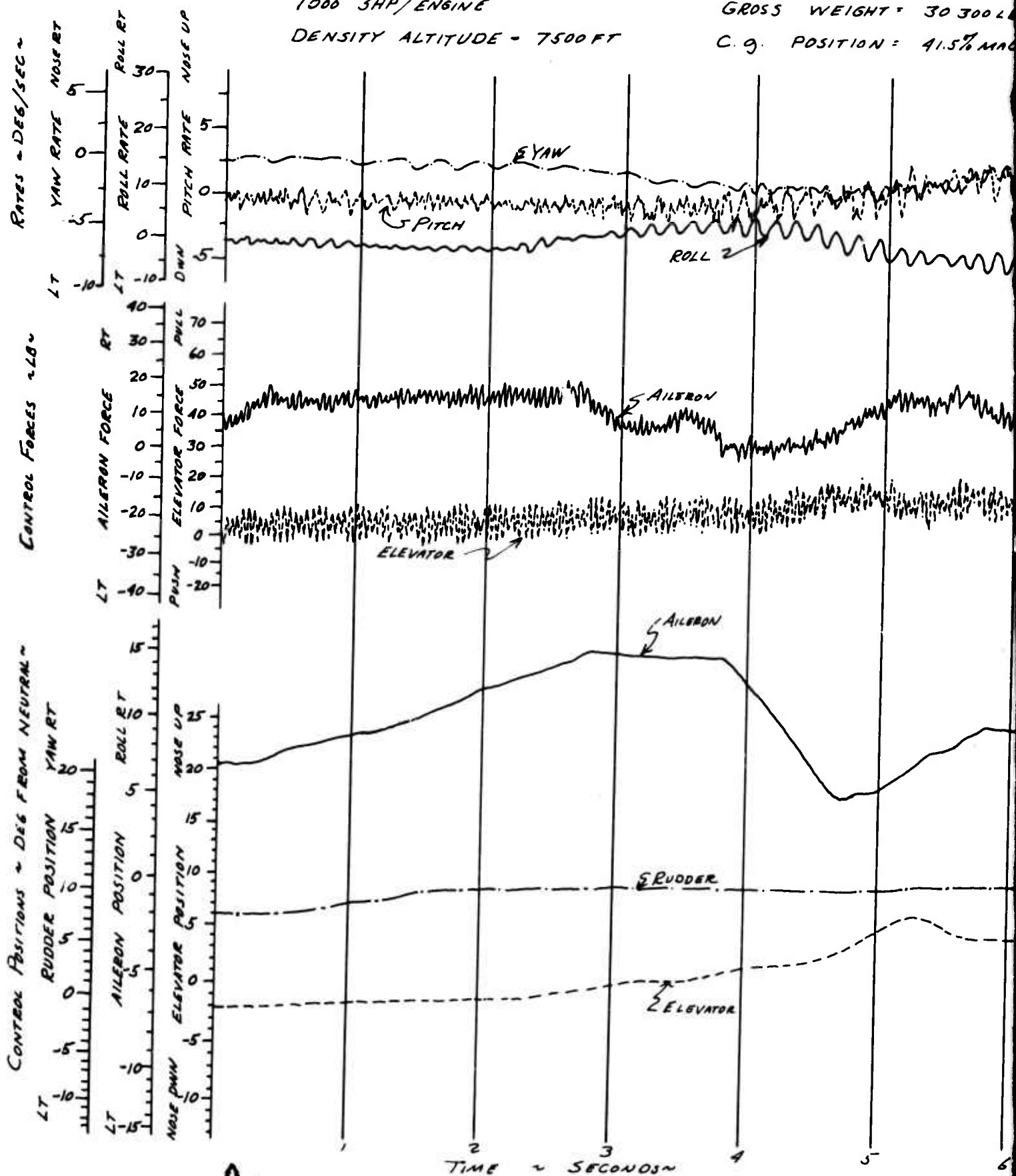
FIGURE NO. 44
TAKE-OFF CONFIGURATION STALL
 CV-7A USA S/N 63-13687
 30 DEGREES OF FLAP

1000 SHP/ENGINE

GROSS WEIGHT = 30 300 LB

DENSITY ALTITUDE = 7500 FT

C.G. POSITION = 41.5% MAC



2

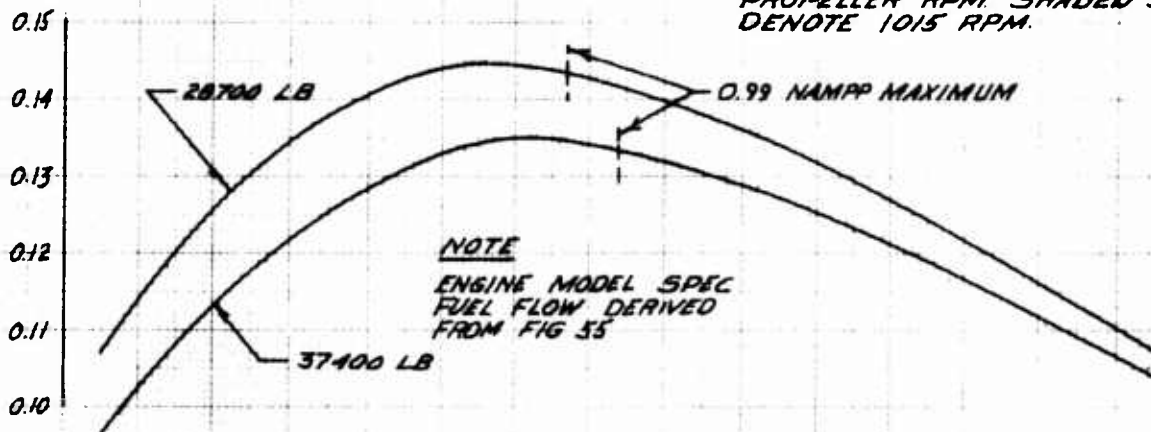
FIGURE No 45
LEVEL FLIGHT PERFORMANCE
CV-7A **USA S/N 63-13687**
U.S. STANDARD DAY
5000 FT

SYMBOL **GROSS WT -LB-**
 □ 28700
 ○ 37400

NOTE

UNSHADED SYMBOLS DENOTE 850
 PROPELLER RPM. SHADED SYMBOLS
 DENOTE 1015 RPM.

SPECIFIC RANGE (NAMPP)
 ~NAUTICAL AIR MILES / LB FUEL~



SHAFT HORSEPOWER (INCLUDES SPEED DECREASES GEAR LOSSES)
 PER ENGINE

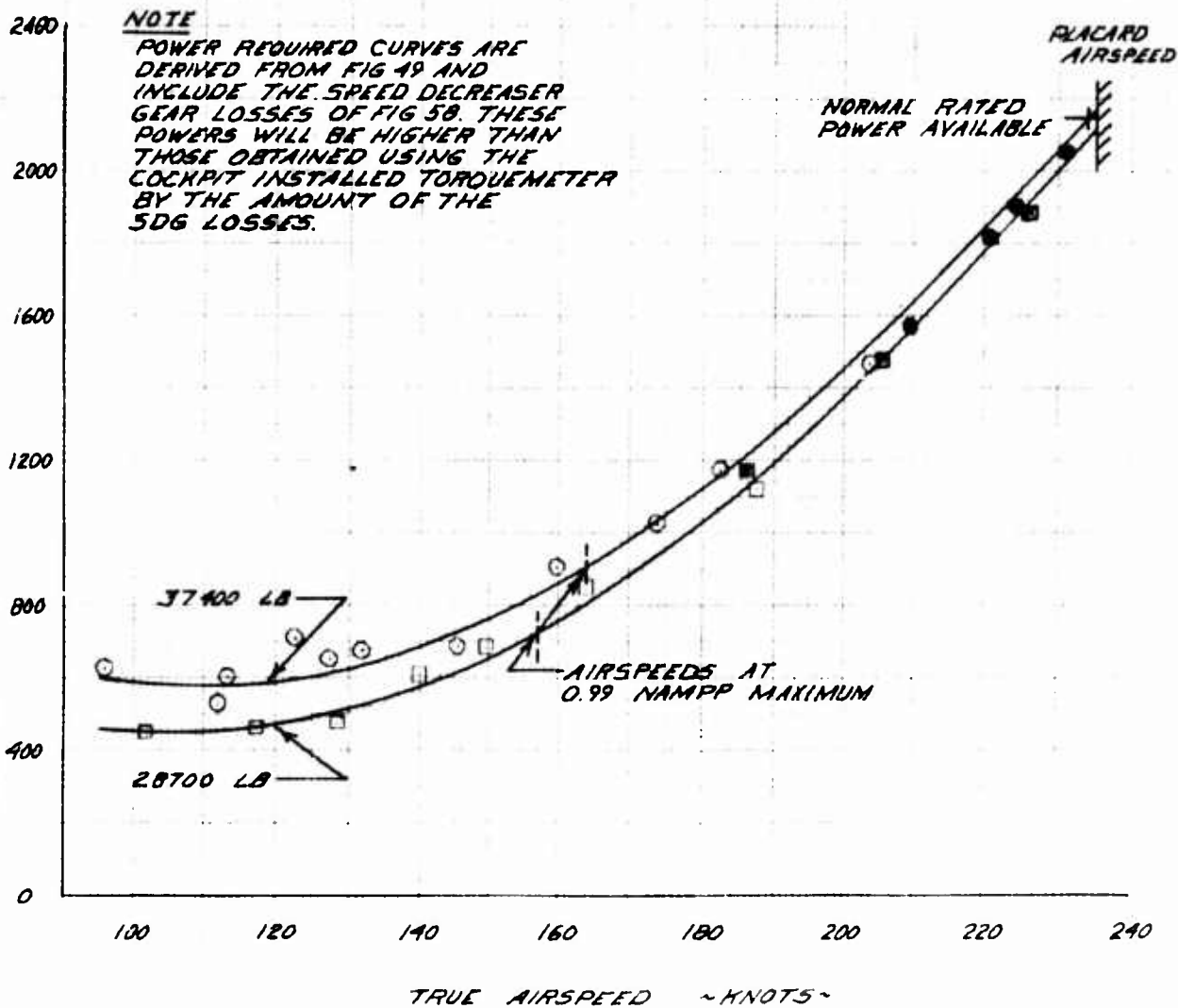


FIGURE NO 46
 LEVEL FLIGHT PERFORMANCE
 CV-7A USA SIN 63-13687
 U.S. STANDARD DAY
 10000 FT

GROSS WT - 37450 LB

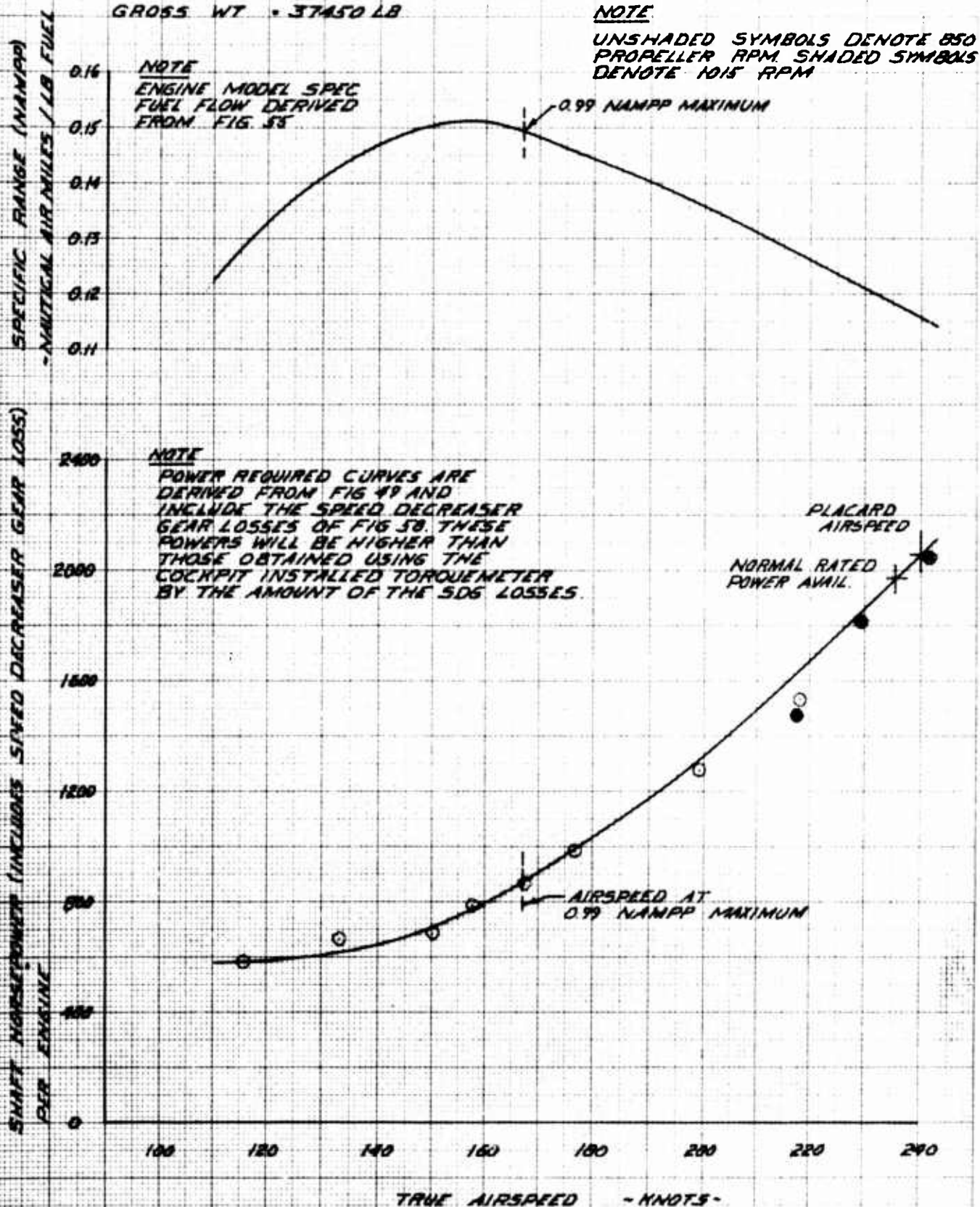


FIGURE NO 47
LEVEL FLIGHT PERFORMANCE
CV-7A **USA S/N 63-13687**
U.S. STANDARD DAY
15000 FT

GROSS WT - 37450 LB

NOTE
 UNSHADED SYMBOLS DENOTE 850
 PROPELLER RPM SHADED
 SYMBOLS DENOTE 1015 RPM

SPECIFIC RANGE (NAMPP) SPECIFIC AIR MILES / LB FUEL

0.17
0.16
0.15
0.14
0.13
0.12

NOTE
 ENGINE MODEL SPEC
 FUEL FLOW DERIVED
 FROM FIG 56

0.99 NAMPP MAX.

2400
2000
1600
1200
800
400
0

NOTE
 POWER REQUIRED CURVES ARE
 DERIVED FROM FIG 49 AND
 INCLUDE THE SPEED DECREASER
 GEAR LOSSES OF FIG 58. THESE
 POWERS WILL BE HIGHER THAN
 THOSE OBTAINED USING THE
 COCKPIT INSTALLED TORQUEMETER
 BY THE AMOUNT OF THE SDG LOSSES.

PLACARD
AIRSPEED

NORMAL RATED
POWER AVAILABLE

AIRSPEED AT
0.99 NAMPP MAXIMUM

100 120 140 160 180 200 220 240

TRUE AIRSPEED ~ KNOTS -

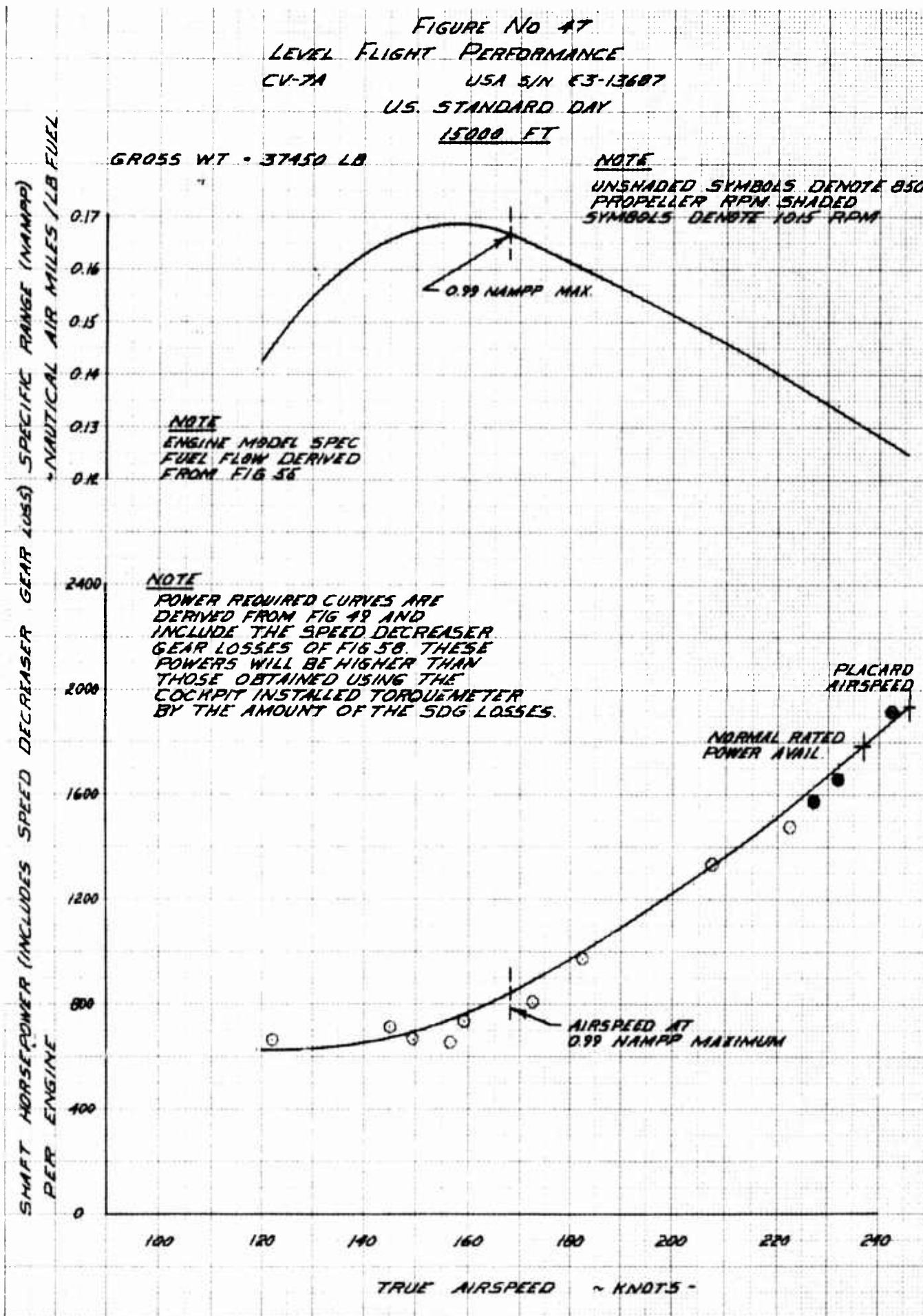


FIGURE No 4B
LEVEL FLIGHT PERFORMANCE
CV-7A **USA G/N 63-13687**
U.S. STANDARD DAY
25000 FT

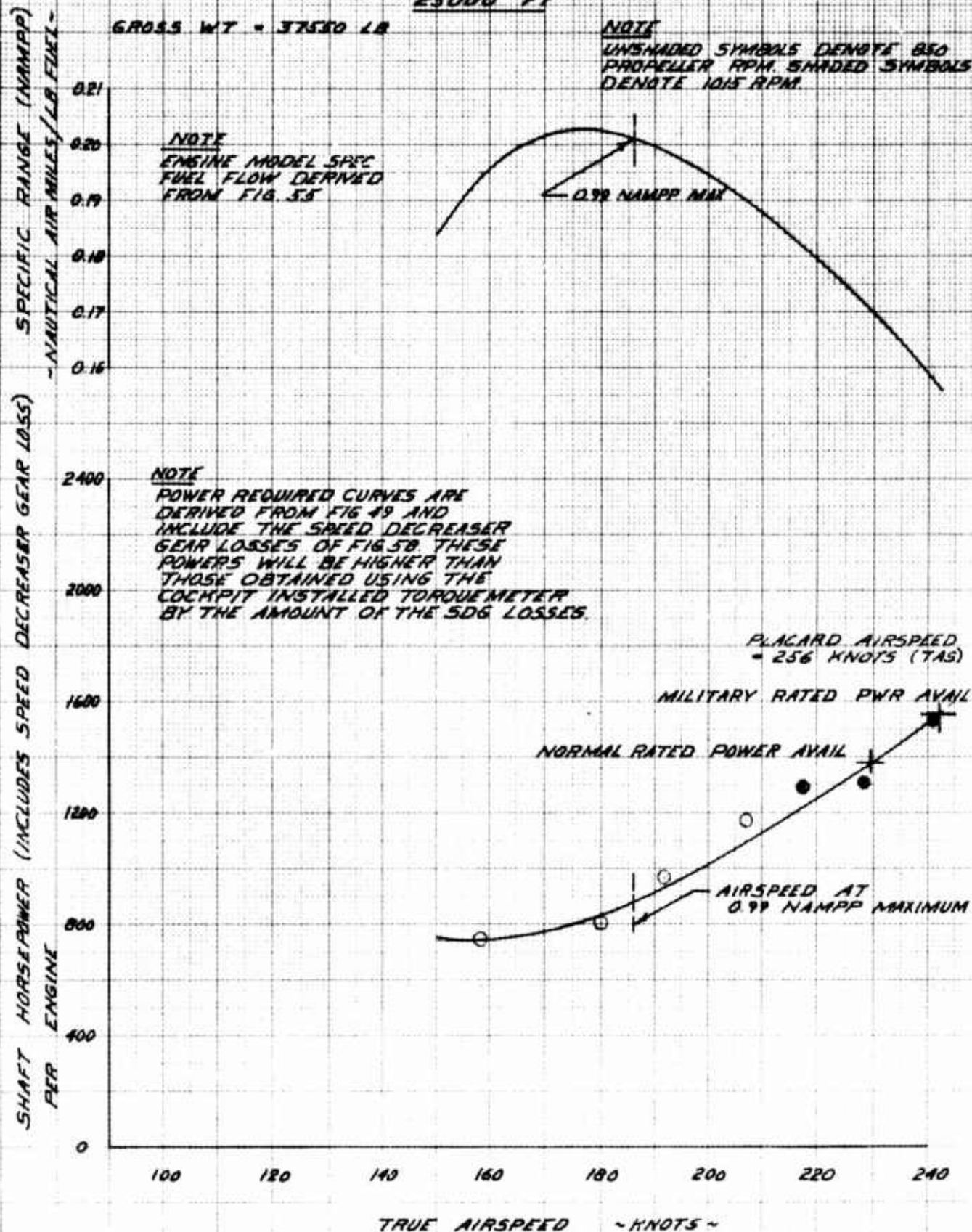


FIGURE NO 49
LEVEL FLIGHT PERFORMANCE
CV-7A **USA SIN 63-13687**

SYMBOL	AVG. PRESS. ALT. - FT.	AVG. GROSS WT. - LB.	AVG. WEIGHT/PRESSURE RATIO (δ_w) - LB.
○	5000	28700	34494
□	5000	37400	44934
◇	10000	37400	54463
△	15000	37450	66356
▽	25000	37530	101146

NOTE
 THESE CURVES DO NOT INCLUDE SPEED DECREASER GEAR LOSSES. THESE POWERS WOULD REPRESENT THE POWER OBTAINED BY USING THE COCKPIT INSTALLED TORQUEMETER

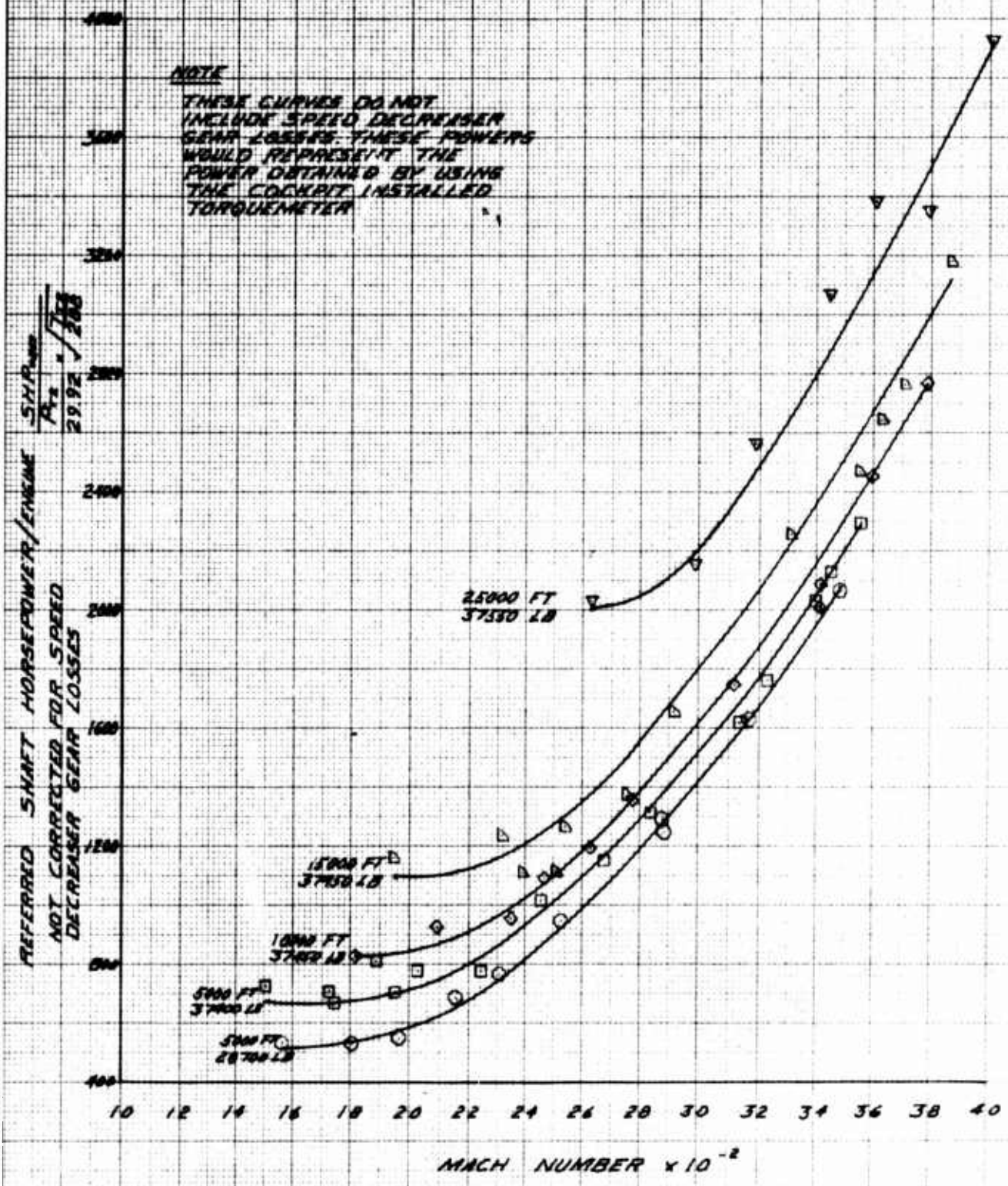


FIGURE No 50
LEVEL FLIGHT PERFORMANCE ~ THP_W vs V_W
CV-7A USA S/N 63-13687

SYMBOL	GROSS WT ~LB~	PRESSURE ALTITUDE ~FT~
○	28700	5000
□	37486	5000
△	37450	10000
▽	37450	15000
◇	37550	25000

WEIGHT STANDARD (W_W) = 38000 LB

NOTE

THE CONTRIBUTION OF
ENGINE JET THRUST
IS NOT INCLUDED IN
THE CALCULATION OF
THRUST HORSEPOWER.

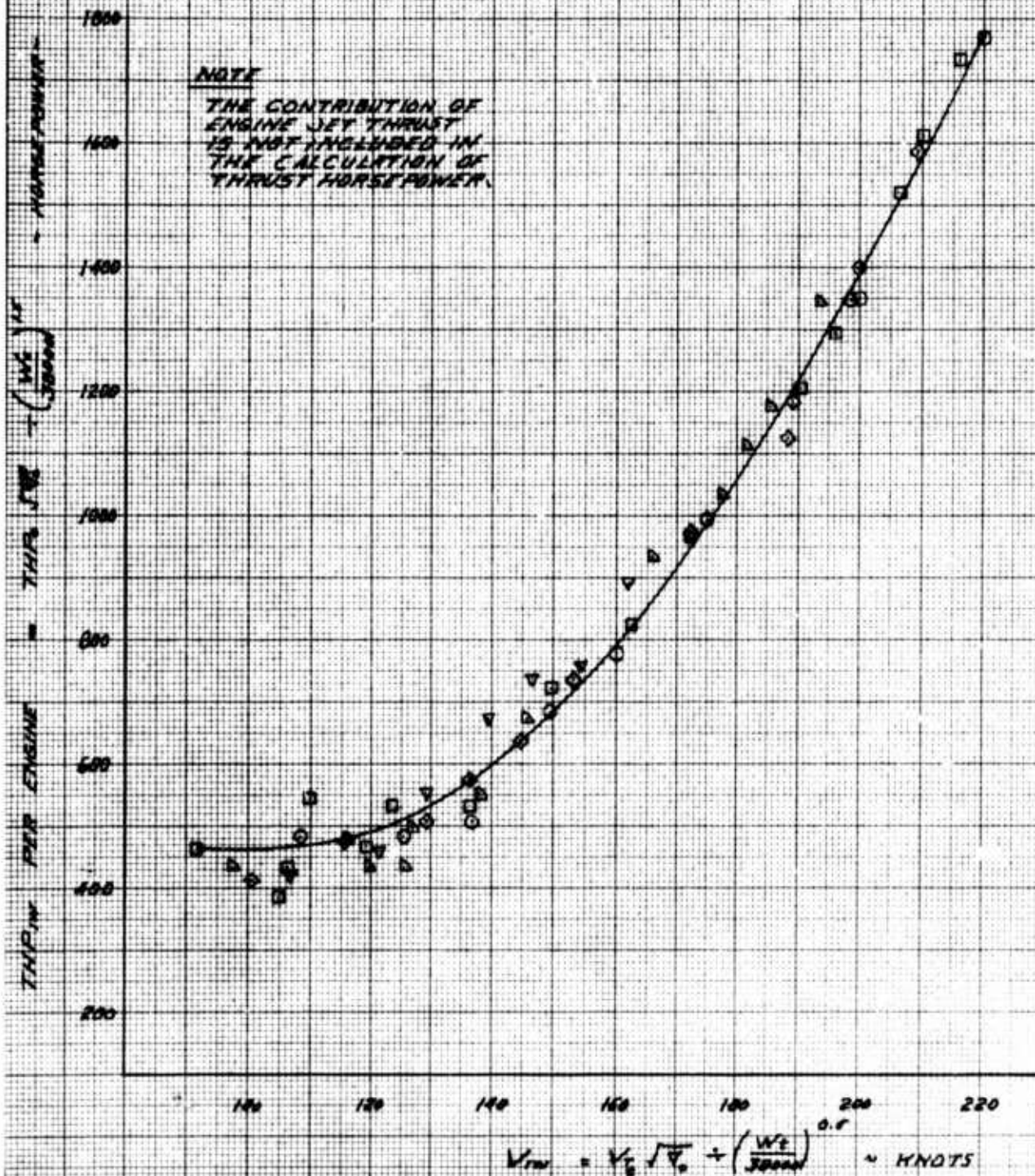


FIGURE NO 51
 SAWTOOTH CLIMB PERFORMANCE
 CV-7A USA S/N 63-13687

TWO ENGINES AT NORMAL RATED POWER
 STANDARD DAY

SYMBOL	ALTITUDE -FT-	GROSS WT -LB-
○	5000	3710
□	10000	3710
△	15000	3710

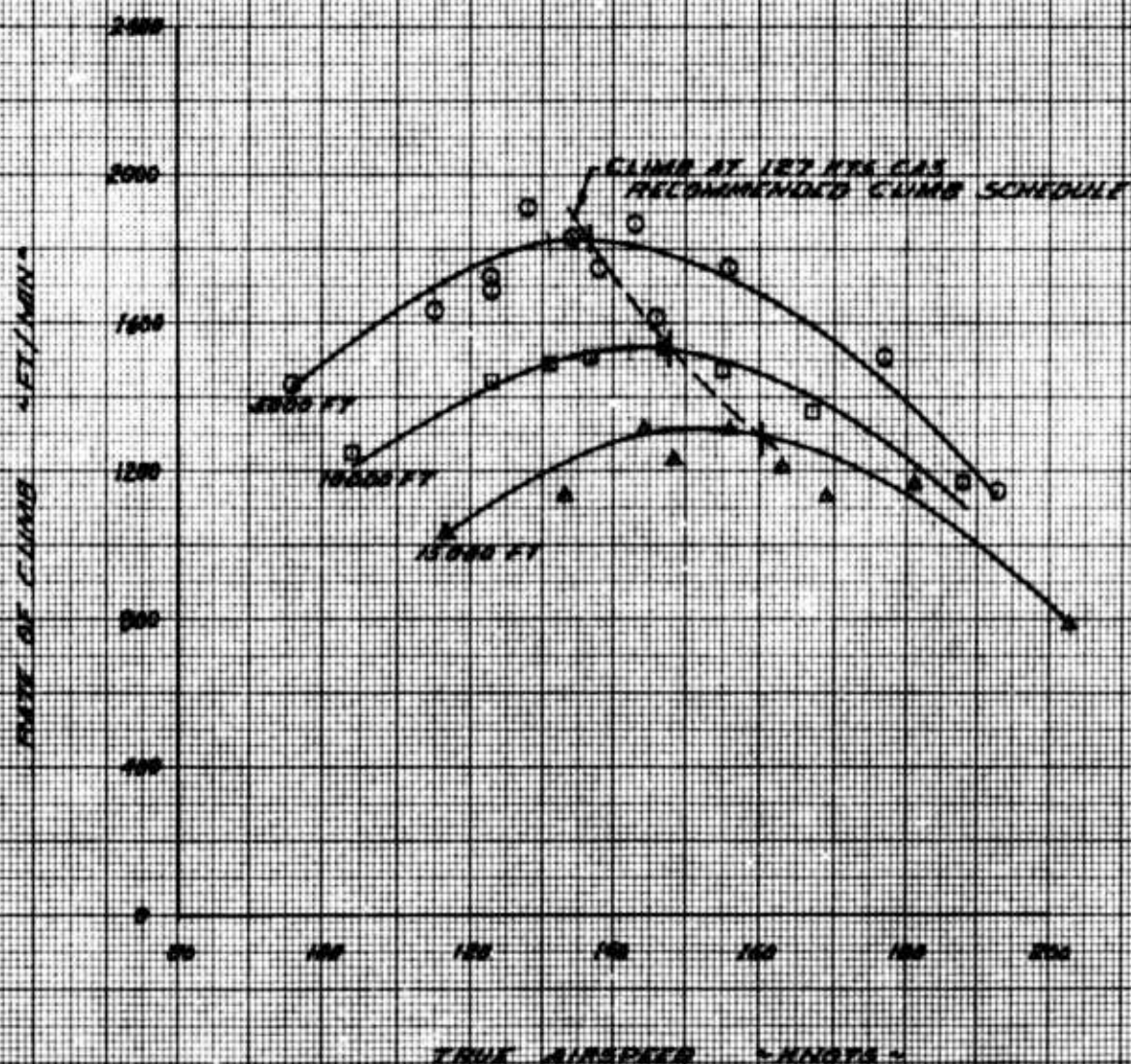


FIGURE NO 52
 SAWTOOTH CLIMB PERFORMANCE
 CV-7A USA S/N 63-13687

ONE ENGINE AT MILITARY RATED POWER
 STANDARD DAY

SYMBOL	GROSS WT ~LB~	ALTITUDE ~FT~
○	37910	5000
□	37810	10000

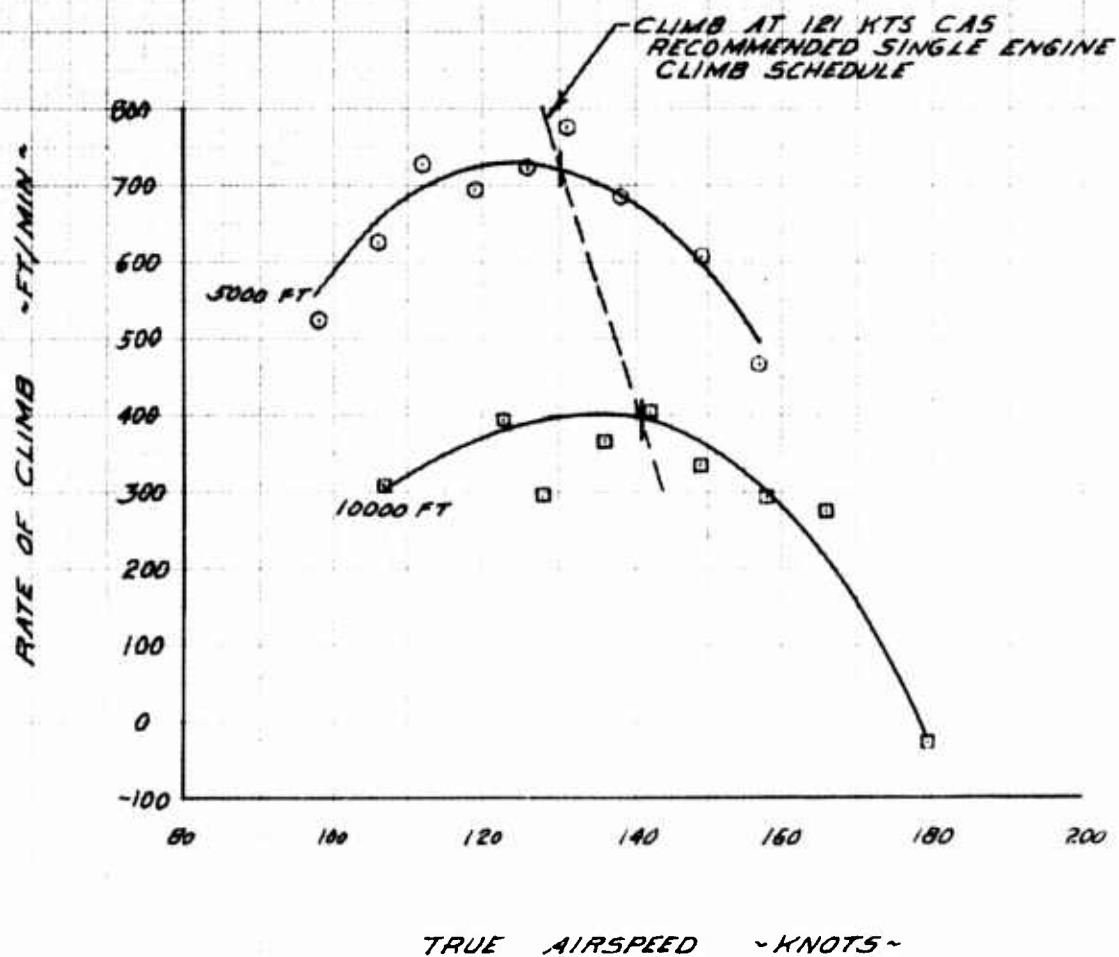


FIGURE No 53
CHECK CLIMB PERFORMANCE
CV-7A USA S/N 63-13687
TWO ENGINES AT NORMAL RATED POWER
STANDARD DAY

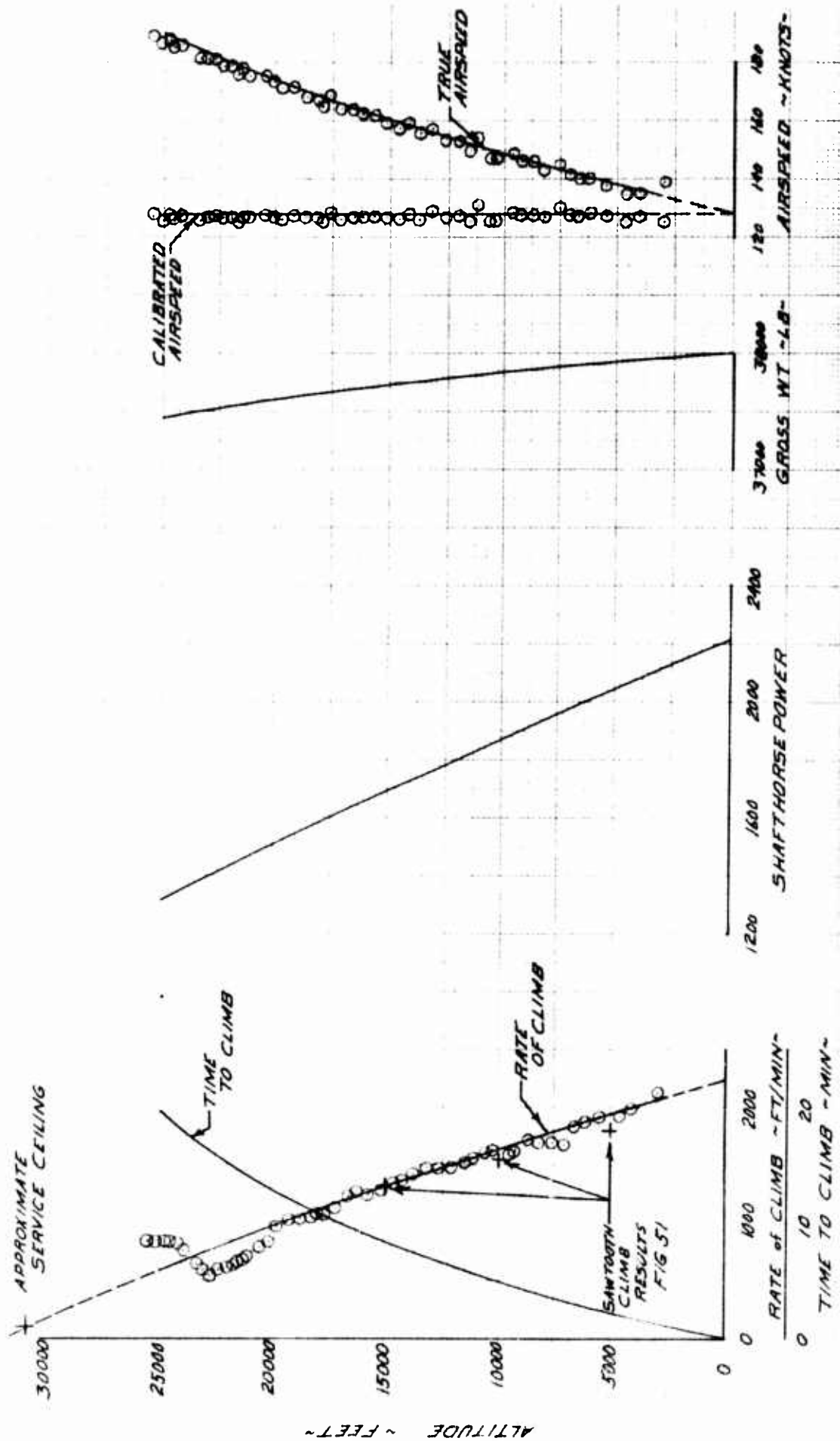
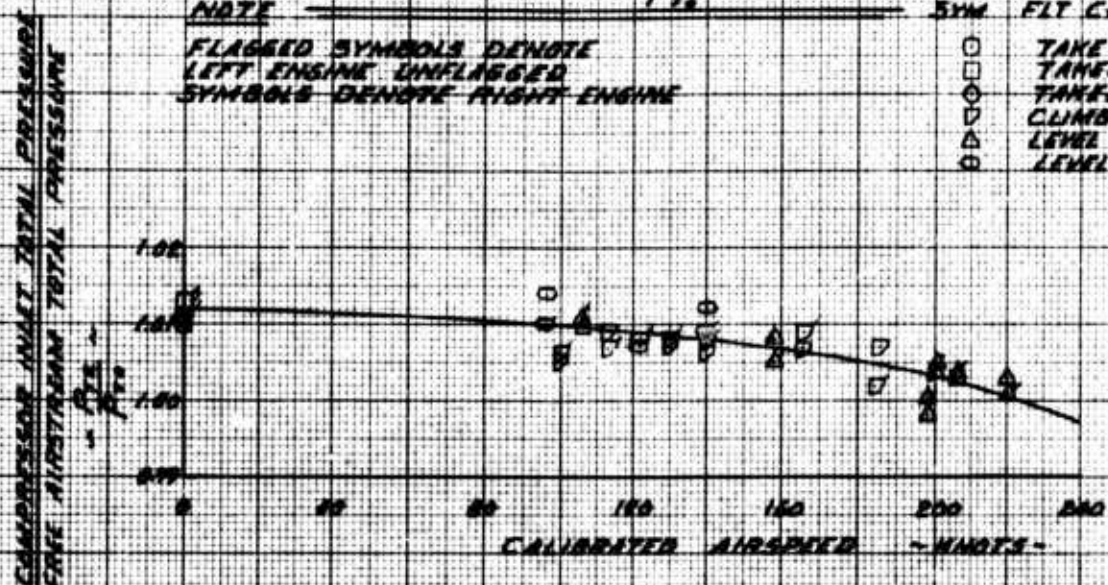


FIGURE NO 54
T-6A-10 INSTALLED ENGINE CHARACTERISTICS AND
COMPRESSOR INLET TOTAL PRESSURE RECOVERY
CV-7A USA SIN 63-13687

COMPRESSOR INLET $\frac{P_{t2}}{P_{t1}}$ RECOVERY

NOTE
 FLAGGED SYMBOLS DENOTE
 LEFT ENGINE UNFLAGGED
 SYMBOLS DENOTE RIGHT ENGINE

SYM	FLT COND	ALTITUDE -FT-
○	TAKEOFF	2200
□	TAKEOFF	6000
◇	TAKEOFF	9600
▽	CLIMB	10000
△	LEVEL FLT	10000
◻	LEVEL FLT	25000



ENGINE CHARACTERISTICS

TAKEOFF POWER ZERO AIRSPEED

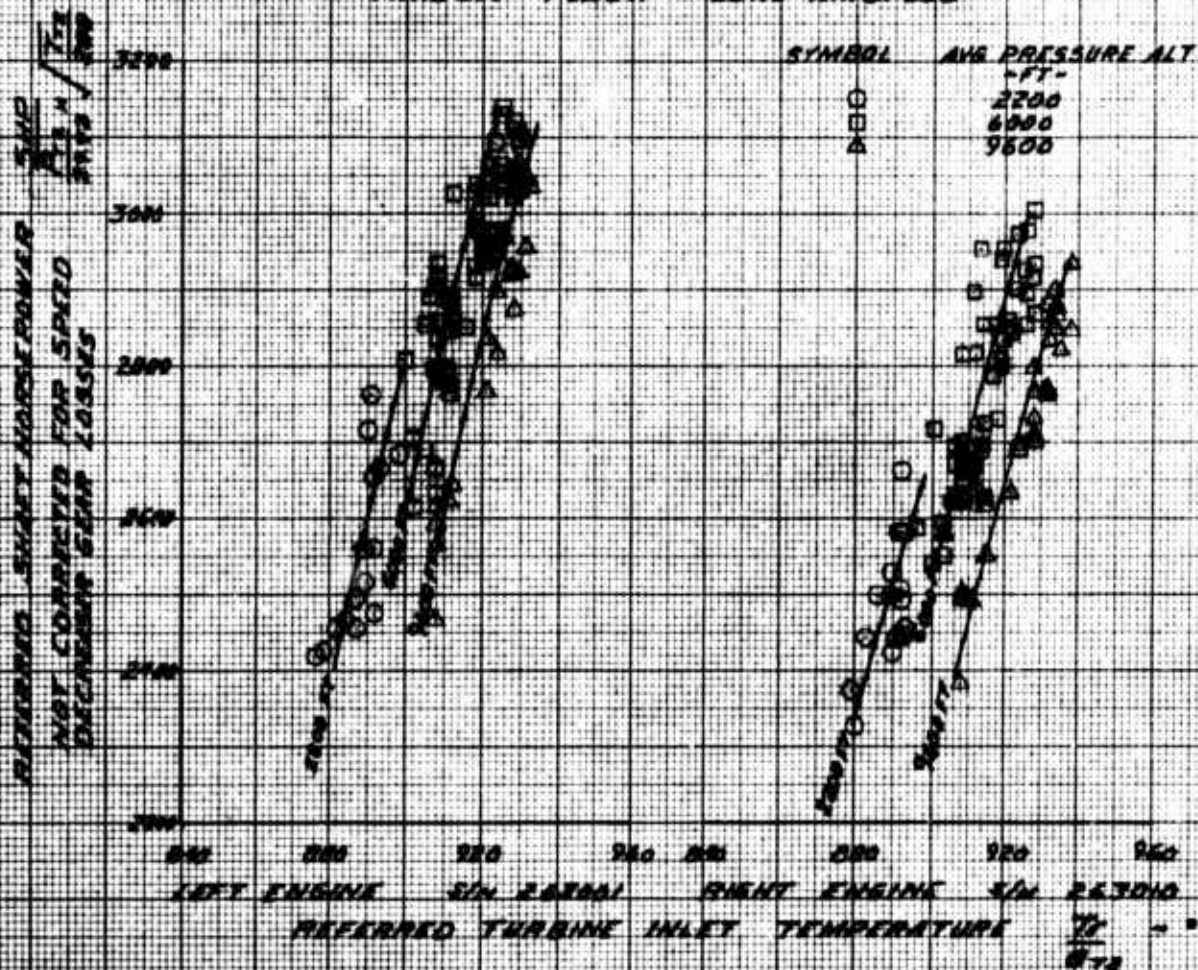
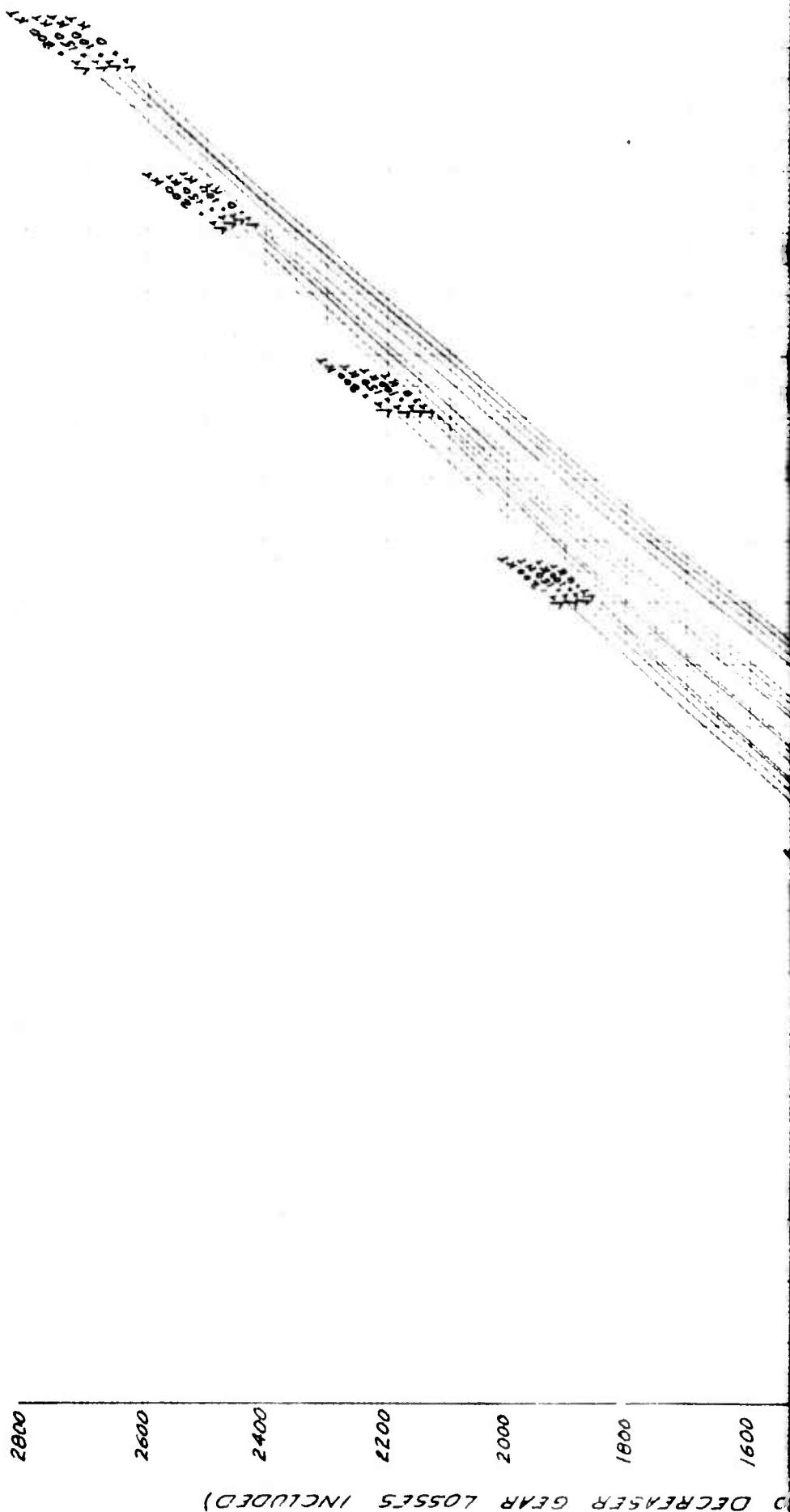


FIGURE NO 55
T-64-10 ESTIMATED MINIMUM PERFORMANCE
CV-7A
USA S/N 63-13687

NOTE

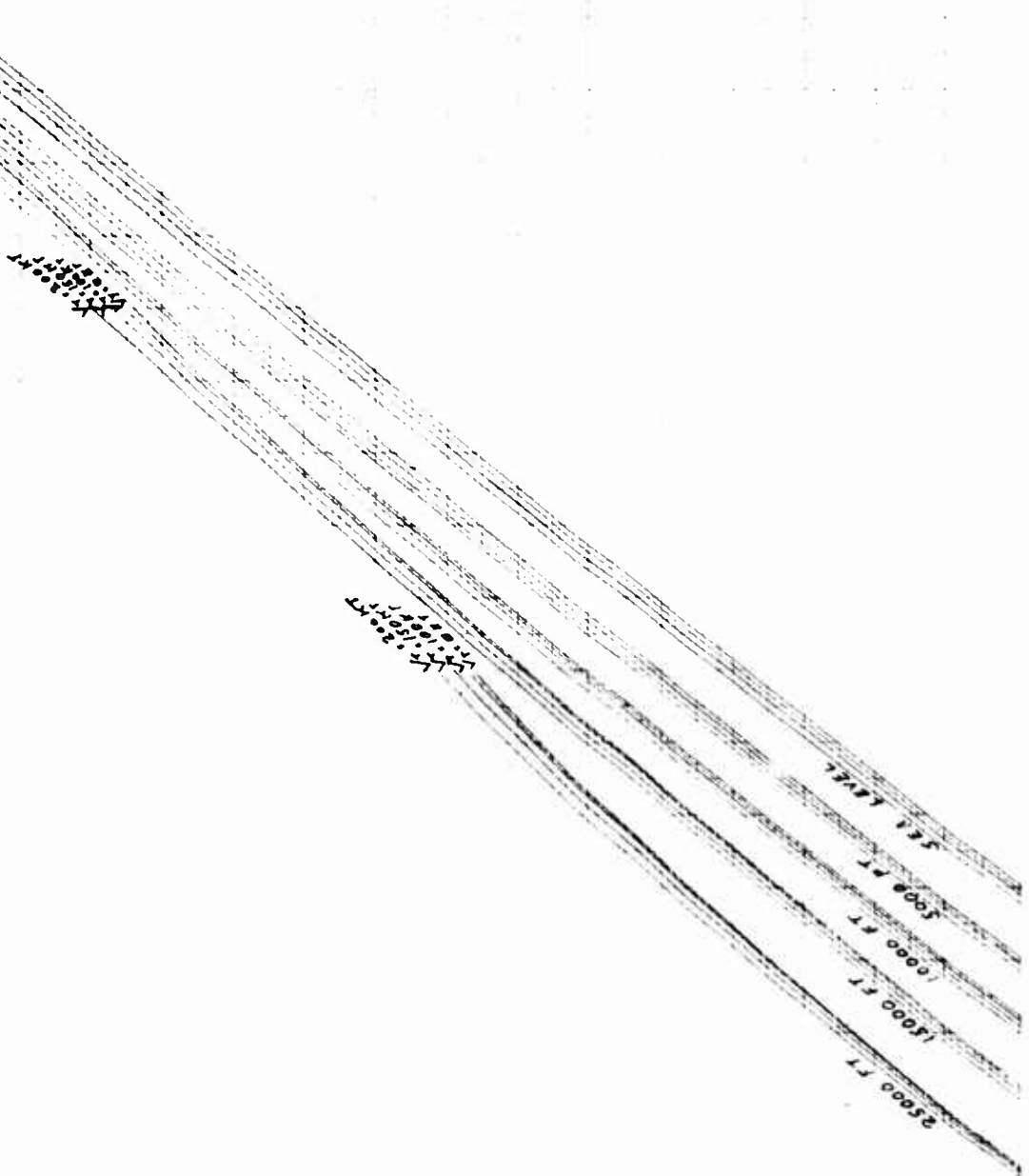
- DATA BASIS T64-GE-10 ENGINE
MODEL SPECIFICATION F1086
WITH THE FOLLOWING INPUTS
- 1 GENERATOR HORSEPOWER EXTRACTED = 10 SHP
 - 2 EXHAUST DUCT LOSS = 0.99 (ASSUMED)
 - 3 COMPRESSOR INLET TOTAL PRESSURE
AS DEFINED BY FIG
 - 4 EXHAUST AREA = 227 SQ. IN.
 - 5 PROP RPM = 850
 - 6 ZERO COMPRESSOR INLET TOTAL TEMPERATURE
RISE
 - 7 U.S. STANDARD DAY



2

SHAFT HORSEPOWER (SPEED DECREASER GEAR 40

2000
1800
1600
1400
1200
1000
800
600



400 500 600 700 800 900 1000 1100 1200 1300

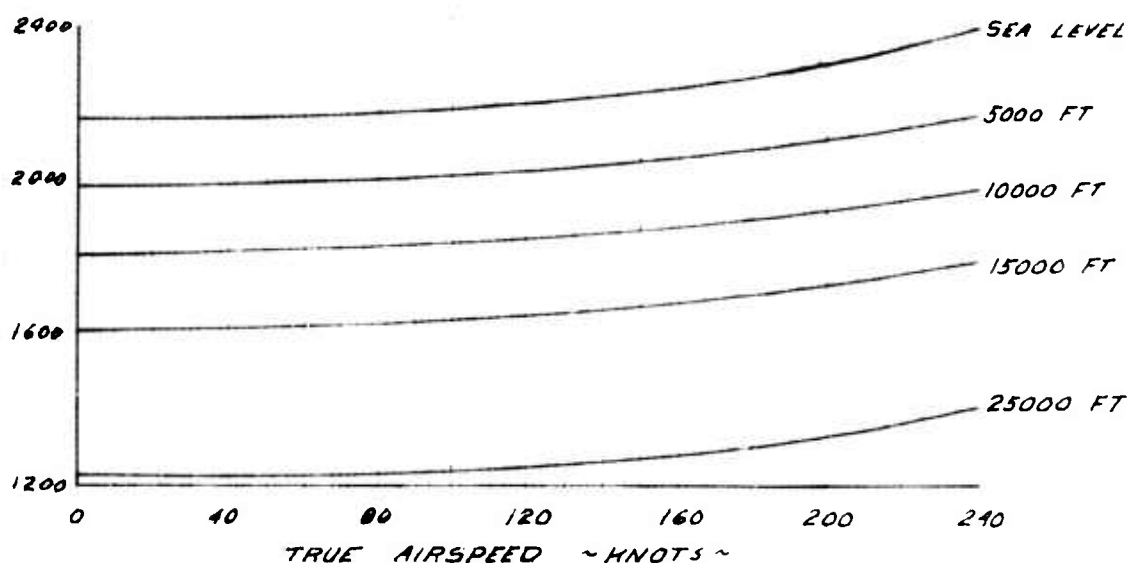
FUEL FLOW ~ LB/HR ~

FIGURE No 56
T-64-10 ESTIMATED MINIMUM POWER AVAILABLE
CV-7A USA S/N 63-13687

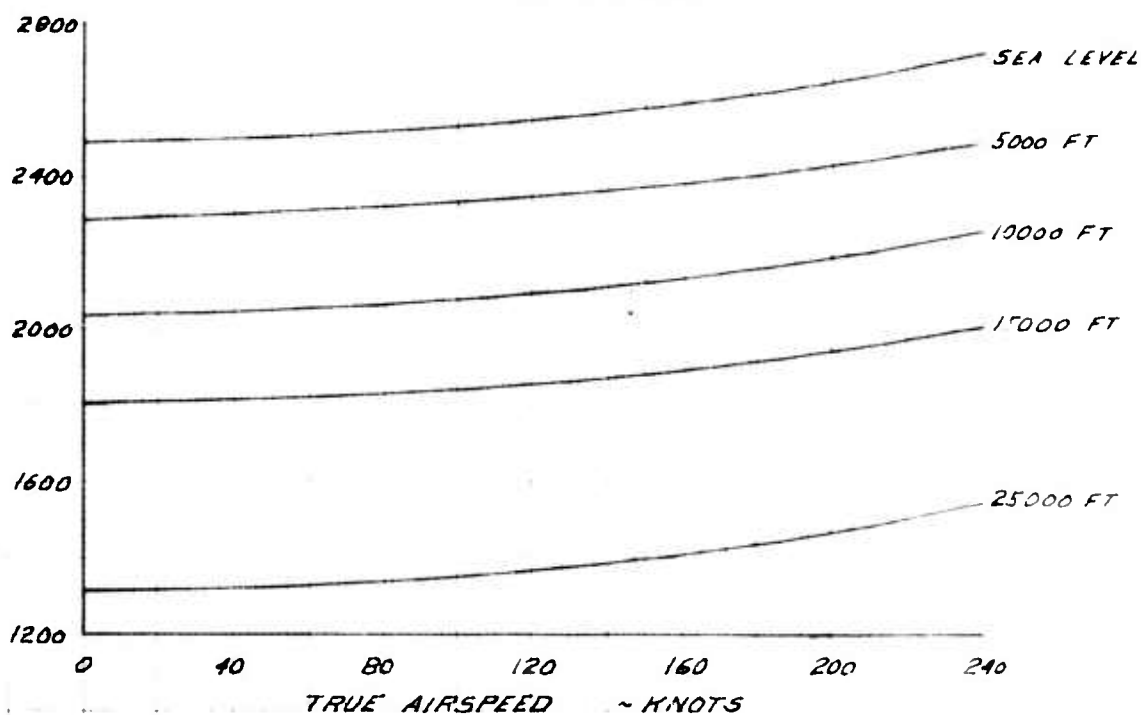
NOTE

DATA BASIS T-64-GE-10 ENGINE
MODEL SPECIFICATION E1086
WITH THE FOLLOWING INPUTS
1 GENERATOR SHP EXTRACTED = 10 SHP
2 EXHAUST DUCT LOSS = 0.99 (ASSUMED)
3 COMPRESSOR INLET TOTAL PRESSURE
AS DEFINED BY FIG
4 EXHAUST AREA = 227 SQ IN
5 PROP RPM = 1015 NORMAL = 1160 MILITARY
6 COMPRESSOR INLET TOTAL TEMP. RISE = 0
7 US STANDARD DAY

NORMAL RATED POWER



MILITARY RATED POWER



SHAFT HORSEPOWER (SPEED DECREASED GEAR LOSSES INCLUDED)

FIGURE NO 57
T64-10 ESTIMATED MINIMUM TAKEOFF POWER AVAILABLE
CV-7A USA S/N 63-13687

NOTE

DATA BASIS T-64-GE-10 ENGINE
MODEL SPECIFICATION E1086
WITH THE FOLLOWING INPUTS:
1 GENERATOR SHP EXTRACTED - 5 SHP
2 EXHAUST DUCT LOSS - 0.99 (ASSUMED)
3 COMPRESSOR INLET TOTAL PRESSURE
AS DEFINED BY FIG
4 EXHAUST AREA - 227 SQ IN
5 PROP RPM - 1160
6 COMPRESSOR INLET TOTAL TEMPERATURE
RISE - 0
7 U.S. STANDARD DAY
8 ZERO AIRSPEED

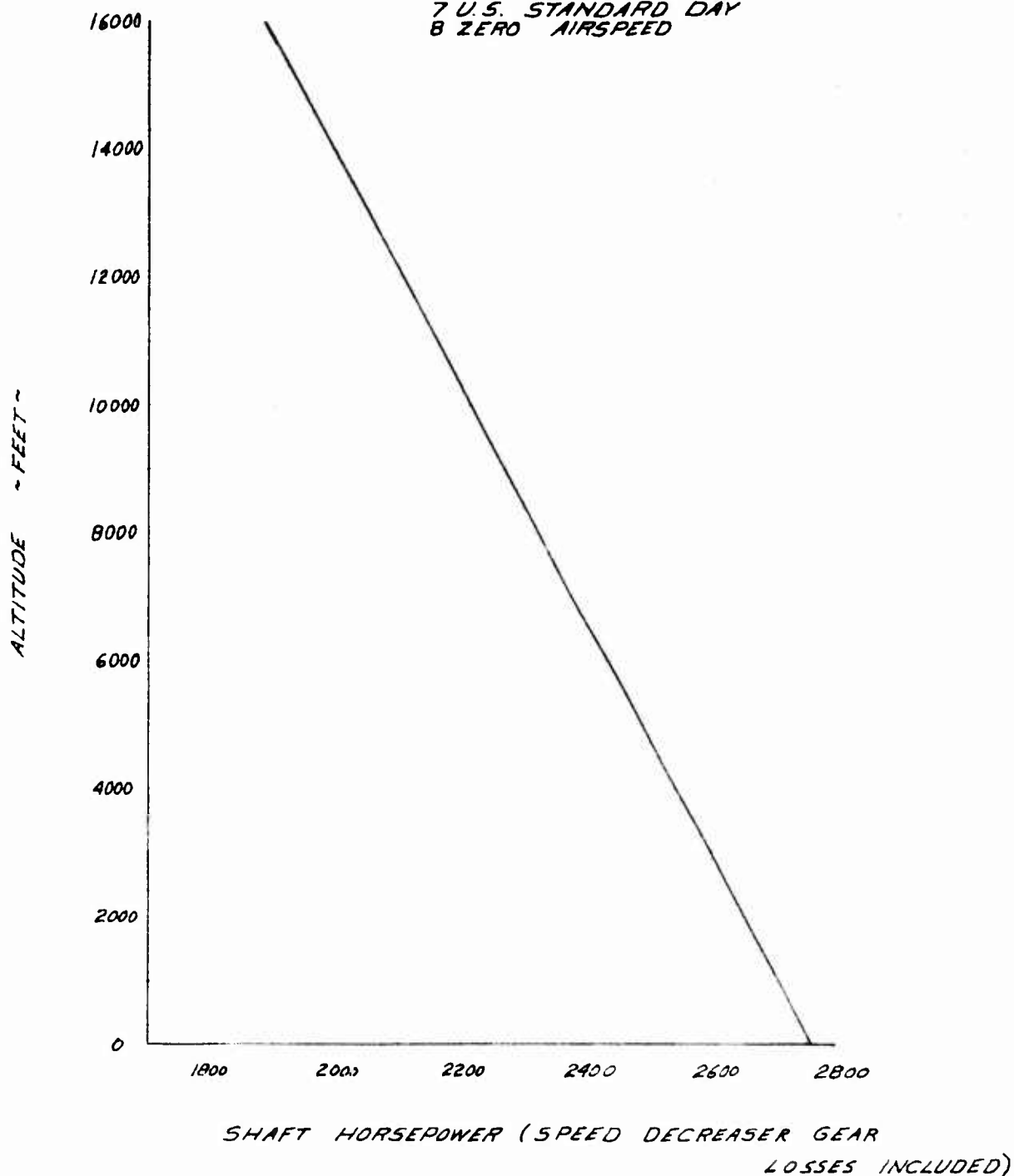
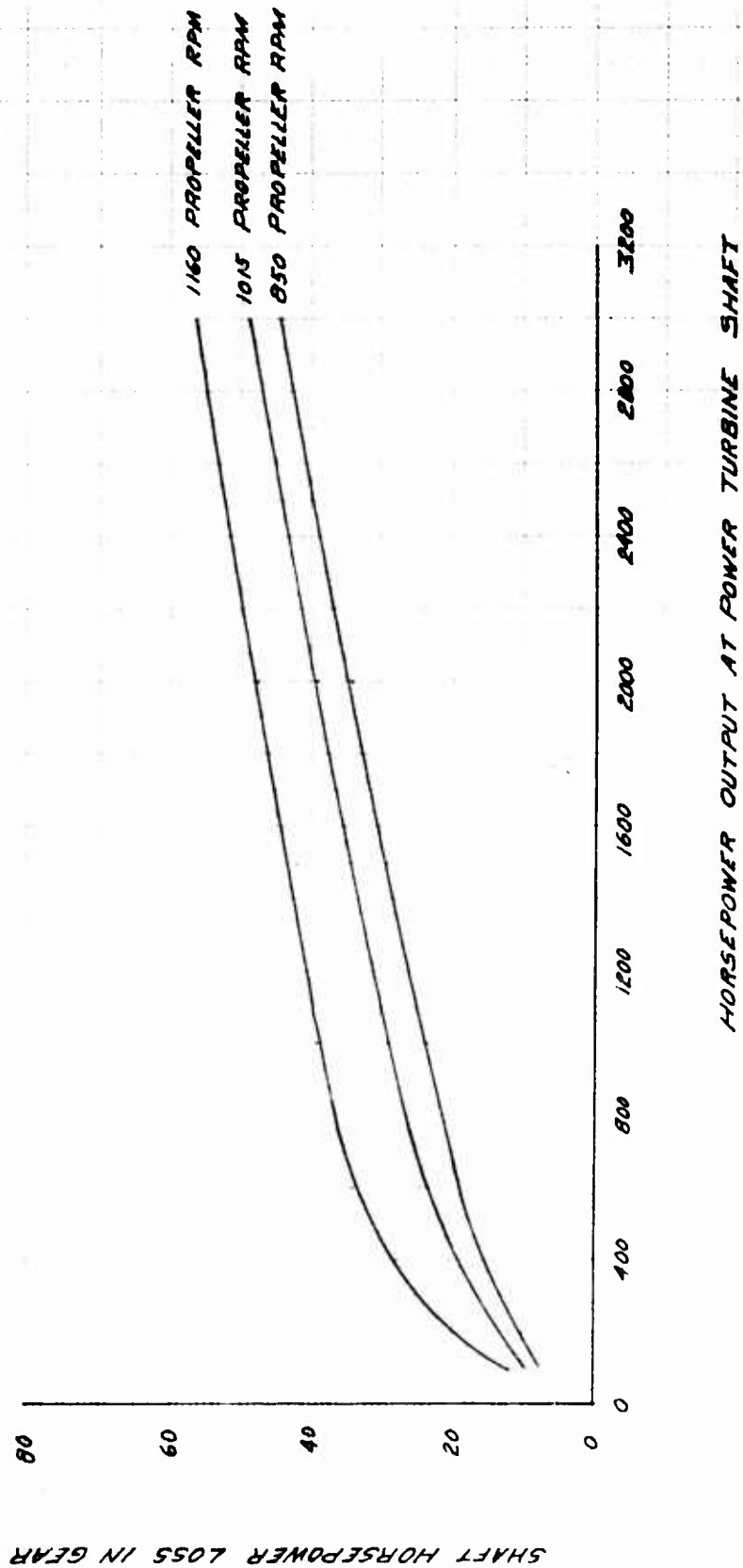
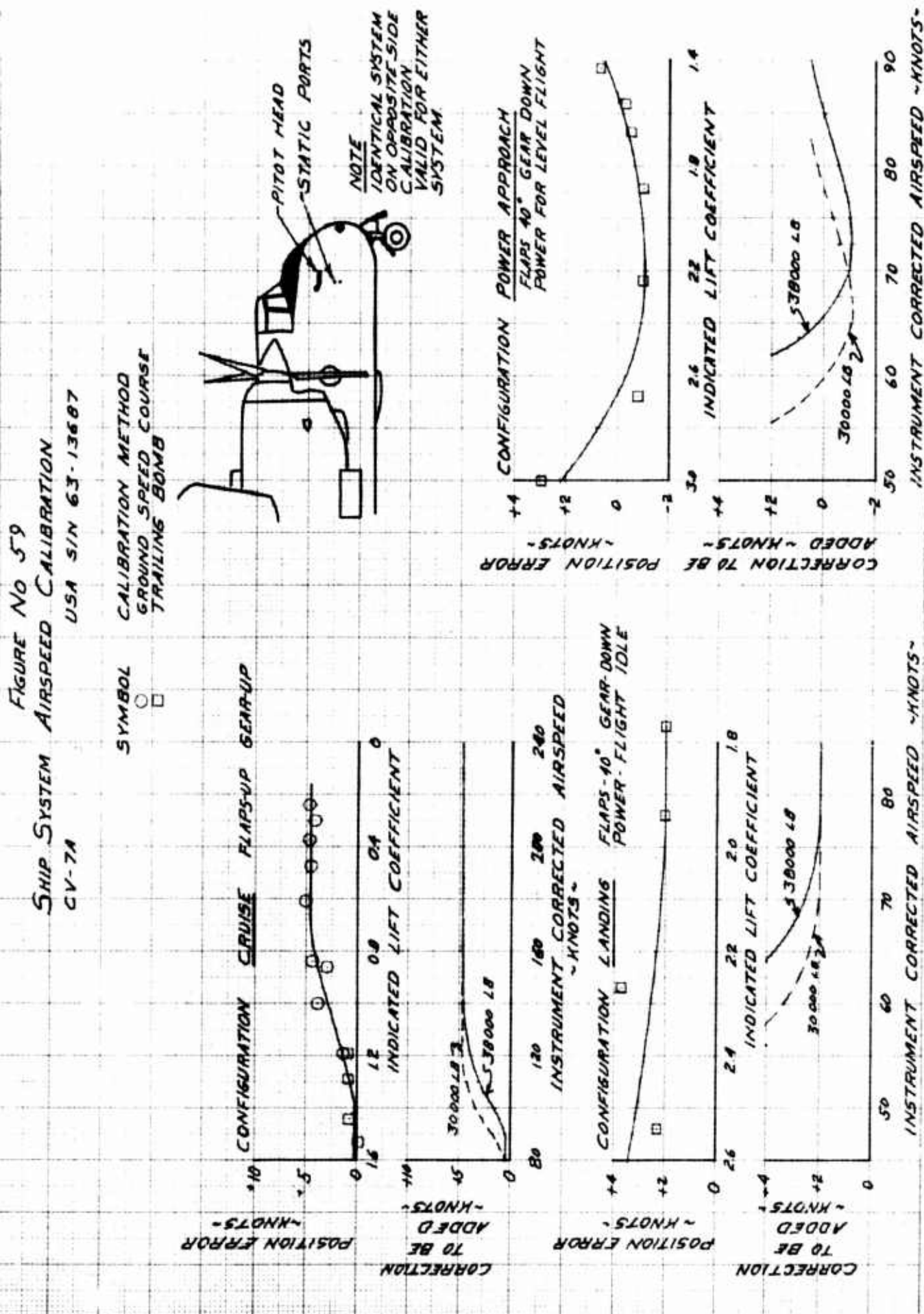


FIGURE NO 58
ESTIMATED SPEED DECREASER GEAR POWER LOSS
CV-7A
T-64-10 ENGINE
USA S/N 63-13687

NOTE
CURVES OBTAINED FROM GENERAL
ELECTRIC MST CURVE E-1914
DATED 1-22-60



SHIP SYSTEM AIRSPEED CALIBRATION
CV-7A
USA SIN 63-13687



APPENDIX II - NOMENCLATURE AND DATA ANALYSIS METHOD

1.0 NOMENCLATURE

<u>Symbol</u>	<u>Description</u>	<u>Units</u>
S	Wing Area	sq ft
C	Wing Chord	ft
MAC	Mean Aerodynamic Chord Width	ft
b	Wing Span	ft
e	Airplane Efficiency	--
AR	Aspect Ratio	--
C.G.	Center of Gravity	% of MAC
SHP	Shaft Horsepower	$\frac{\text{ft-lb}}{\text{min}} \times \frac{1}{33,000}$
THP	Thrust Horsepower	$\frac{\text{ft-lb}}{\text{min}} \times \frac{1}{33,000}$
n	Propeller Efficiency	--
NRP	Normal Rated Power	SHP
MRP	Military Rated Power	SHP
TOP	Takeoff Power	SHP
RPM	Propeller RPM	revolutions/min
N ₂	Power Turbine Output Speed	revolutions/min
p	Rate of Roll	radians/sec
PLF	Power for Level Flight	SHP
V _{mc}	Minimum Control Airspeed	kt

<u>Symbol</u>	<u>Description</u>	<u>Units</u>
N_o	Stick-Fixed Neutral Point	% of MAC
N_o'	Stick-Free Neutral Point	% of MAC
δ_e	Elevator Position	degree
δ_a	Aileron Position	degree
δ_r	Rudder Position	degree
F_e	Elevator Force	lb
F_a	Aileron Force	lb
"g"	Acceleration of Gravity	32.2 ft/sec ²
T	Temperature	° Kelvin
p	Air Pressure	in. Hg
H	Pressure Altitude	ft
ρ	Air Density	slug/ft ³
δ	$P + 29.92$	--
σ	$\rho + .002378$	--
M	Mach Number	--
TAS	True Airspeed	kt
IAS	Indicated Airspeed	kt
CAS	Calibrated Airspeed	kt
R/C	Rate of Climb	ft/min
GW	Gross Weight	lb
W_f	Fuel Flow	lb/hr
NAMPP	Specific Range	Nautical Air Miles/ lb of fuel

<u>Subscripts</u>	<u>Description</u>
T	Total Temperature of Pressure
t	Test Conditions
S	Standard Conditions
a or o	Ambient Conditions
P	Pressure
d	Density
1	Engine Inlet
2	Compressor Inlet
5	Power Turbine Inlet
7	Tailpipe Inlet
8	Exhaust Gas Outlet

2.0 DATA ANALYSIS METHODS

2.1 TAKEOFF PERFORMANCE

Takeoff performance was corrected to a zero-wind, zero-slope runway condition on a standard day at an even altitude near the test altitude at which the corrections of Reference (n) were minimized. Corrections for variations from standard of gross weight, density and shaft horsepower were made using the techniques developed in Reference (n). Test gross weight was controlled to within $\pm 1\%$ of the target standard gross weight by adding ballast as fuel was used.

All takeoffs were recorded with two Fairchild Flight Analyzers positioned to cover the entire flight path with sufficient overlap to allow correlation. Ground roll distance and total distance to clear a 50-foot obstacle were reduced for each takeoff as well as true airspeeds at lift-off and 50 feet.

Wind velocities and directions were recorded at both 6 feet and 50 feet at a point near lift-off.

Shaft horsepower corrections to standard were made by recording the static takeoff power available under test conditions and correcting this to the specification power available under standard conditions, calculated using measured inlet conditions.

2.2 LANDING PERFORMANCE

Landing performance was corrected to a zero-wind condition on a standard day at the test altitude using the methods of Reference (n). No correction for change in gross weight was used; however, the gross weight was controlled to within ± 1 percent of the target gross weight by adding lead ballast as fuel was used.

All landings were recorded with a Fairchild Flight Analyzer. Ground roll distance and total distance to land over a 50-foot obstacle were reduced for each landing as well as true airspeeds at touchdown and 50 feet.

Wind velocities and directions were recorded at both 6 feet and 50 feet at a point near touchdown.

2.3 STABILITY AND CONTROL

All stability and control data was reduced to the formats recommended in Reference (o) for analysis.

2.4 PERFORMANCE

2.4.1 LEVEL FLIGHT

Level flight performance was corrected to standard-day conditions using methods of Reference (m). Tests were flown at a constant W/δ (i.e., successive data points were recorded at increased altitude as fuel was consumed). A plot of CAS or M vs $SHP/\delta T_2 \sqrt{\theta T_2}$ was obtained for each level

7

flight test. Individual level flight performance plots were presented at the target altitude and average gross weight for a particular test by correcting each test point for the change in induced drag caused by the change in weight from the test condition to the average gross weight at which the plot is presented.

Nautical Air Miles/lb of fuel (NAMPP) was obtained for each test with Engine Model Specification fuel flows calculated using test determined inlet conditions.

2.4.2 CLIMB

Climb performance was corrected to standard-day conditions using the methods of Reference (m). Standard-day power available was calculated using the Engine Model Specification with test determined inlet conditions.

Corrections were made to correct the observed rate of climb to a tapeline rate of climb then to a rate of climb on a standard day. Additional corrections were applied to correct for deviation of test weight from the standard weight, change in induced drag due to change in weight, and the difference between test shaft horsepower and standard shaft horsepower.

2.4.3 AIRSPEED CALIBRATION

The airspeed was calibrated using both the ground speed course and the trailing bomb techniques. Data was reduced using the methods outlined in Reference (m).

APPENDIX III - TEST INSTRUMENTATION

Test instrumentation was installed, calibrated and maintained by the Logistics Division of USAAVNTA.

The following parameters were recorded:

a. 50-Channel Oscillograph

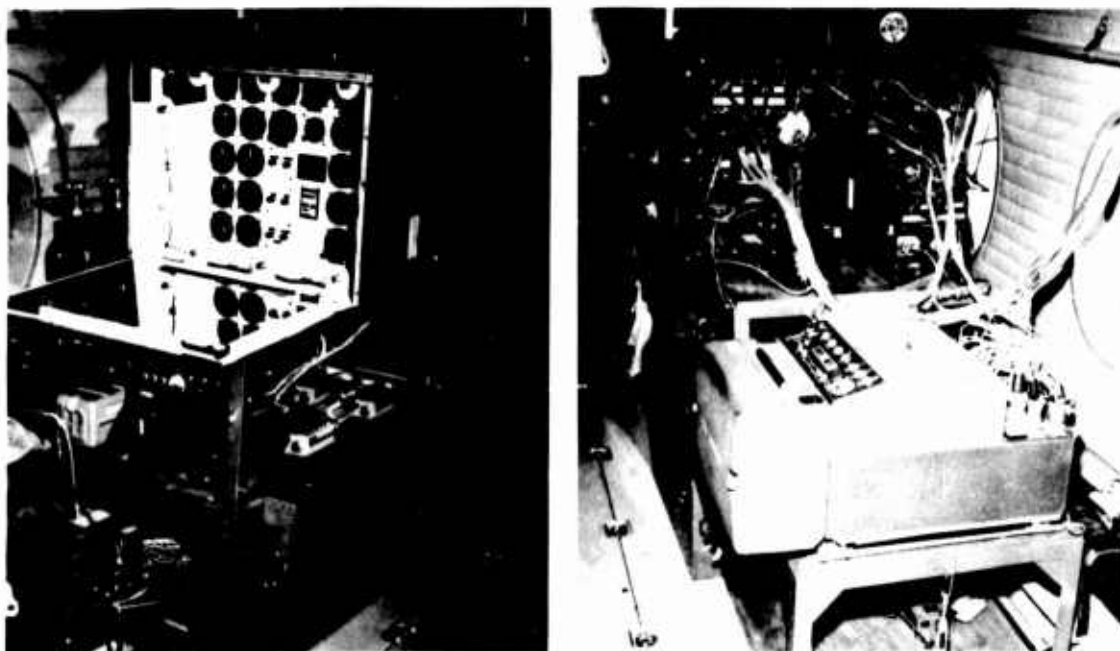
- (1) Elevator Force
- (2) Elevator Position
- (3) Pitch Angle
- (4) Pitch Rate
- (5) Angle of Attack
- (6) Center-of-Gravity Normal Acceleration
- (7) Center-of-Gravity Longitudinal Acceleration
- (8) Aileron Force
- (9) Aileron Position
- (10) Aileron Trim Tab Position
- (11) Right Inboard Spoiler Position
- (12) Left Inboard Spoiler Position
- (13) Roll Angle
- (14) Roll Rate
- (15) Rudder Position
- (16) Yaw Angle
- (17) Yaw Rate
- (18) Angle of Sideslip
- (19) Bridge Balance Voltage
- (20) Pilot Event
- (21) Engineer Event

b. Photo Panel

- (1) Boom System Airspeed
- (2) Boom System Altitude
- (3) Ship System Altitude
- (4) Ship System Airspeed
- (5) Outside Air Temperature
- (6) Left-Engine Propeller RPM
- (7) Right-Engine Propeller RPM
- (8) Left-Engine Gas Generator RPM
- (9) Right-Engine Gas Generator RPM
- (10) Left-Engine Turbine Inlet Temperature
- (11) Right-Engine Turbine Inlet Temperature
- (12) Left-Engine Fuel Flow Indicator
- (13) Right-Engine Fuel Flow Indicator
- (14) Left-Engine Fuel Totalizer
- (15) Right-Engine Fuel Totalizer

- (16) Left-Engine Compressor Inlet Temperature
- (17) Right-Engine Compressor Inlet Temperature
- (18) Left-Engine Compressor Inlet Pressure
- (19) Right-Engine Compressor Inlet Pressure
- (20) Fuel Temperature
- (21) Pilot Event
- (22) Engineer Event
- (23) Main Landing Gear Oleo Extension Light
- (24) Flap Position Indicator
- (25) Longitudinal Control Yoke Position
- (26) Clock
- (27) Stop Watch

A test airspeed system consisting of an airspeed boom was installed on the right wing near the tip. The boom extended approximately 60 inches from the leading edge of the wing. A pitot tube and static source were located at the tip of the boom on a yaps head.



FLIGHT TEST INSTRUMENTATION

APPENDIX IV - GENERAL AIRCRAFT INFORMATION

1.0 AIRCRAFT DESCRIPTION

The CV-7A "Buffalo" is an all-metal, high-wing, twin-engine, tricycle-gear airplane and is a growth version of the CV-2B "Caribou." The airplane is designated as a medium troop/cargo STOL transport with a 3-5 ton payload capability. The airplane is capable of instrument day and night operations from hastily prepared and/or selected unprepared surfaces. Power is supplied by two T-64-GE-10 turbo-prop engines equipped with Hamilton Standard 63E60-13 constant-speed, variable and reversible pitch propellers. The propellers are characterized by additional low pitch stops. One of these is used for STOL approaches (approach stop) and one is used for taxiing (ground fine stop). The tricycle landing gear, hydraulically actuated, is fully retractable. Electrically operated cargo and ramp doors in the rear of the airplane are used for loading and unloading troops and cargo. High-lift devices incorporated in the airplane consist of hydraulically-actuated, double-slotted, root and mid trailing flaps. Normal flight crew consists of a pilot, copilot and crew chief. Seating for 34 fully equipped troops is provided in the main cabin with provisions for 7 additional forward-facing seats along the cabin longitudinal centerline. Fuel is contained in four main tanks with a total fuel capacity of 2086 gallons.

2.0 AIRCRAFT DIMENSIONS AND DESIGN DATA

a. General

(1) Span	96 ft
(2) Height of vertical tail over static ground line	28 ft 8 in
(3) Overall length	77 ft 3.8 in
(4) Track of main wheels	30 ft 6 in

b. Wing

(1) Root chord (Aerofoil NACA 64 ₃ A417.5)	141.25 in
(2) Tip chord (Aerofoil NACA 63 ₂ A615)	78 in
(3) Mean aerodynamic chord	123 in
(4) Aspect ratio	9.85
(5) Area (projected)	945 sq ft

c. Vertical Tail

(1) Root chord	168 in
(2) Tip chord	100 in
(3) Height	163 in
(4) Aspect ratio	1.22
(5) Area	162 sq ft

d. Horizontal Tail

(1) Root chord (Aerofoil NACA 63A214 inverted and modified)	100 in
(2) Tip chord	75 in
(3) Span	38 ft
(4) Aspect ratio	4.41
(5) Area	233 sq ft

e. Maximum Control Deflections

(1) Aileron (flaps Up)	Up 18° Down 18°
(2) Aileron (flaps Down)	Up 23°30' Down 18°
(3) Spoilers (inboard flt mode)	Up 27°30'
(4) Spoilers (inboard landing mode)	Up 48° 30'
(5) Elevator	Up 25° Down 15°
(6) Rudder (forward rudder)	Left 25° Right 25°
(7) Rudder (trailing rudder)	Left 25° Right 25°
(8) Flap (root fore flap)	Down 40°

3.0 CONTROL DISCRIPTION

The primary flight control surfaces are operated from the flight compartment in the conventional manner by cables from dual control columns and dual rudder pedals which allow the airplane to be flown from either the pilot's or copilot's position. An aileron on each wing

is hinged to arms at the trailing edge of an outboard fore flap and droops with the flaps. The range of aileron movement varies with flap deflection. Two spoilers located in each wing deploy separately to supplement lateral control in flight. The spoilers are used in conjunction with the ailerons in normal flight and deploy simultaneously upon landing to spoil wing lift. An approximately 5-degree movement in the control wheel is required before the spoilers begin to supplement lateral control. The ailerons are unboosted, whereas the spoilers are hydraulically boosted. The ailerons are mass-balanced and incorporate geared tabs to provide aerodynamic assistance. An electrically-operated trim tab is also installed on the right-hand aileron and a rudder-aileron interconnect tab on the left-hand aileron.

The elevators are operated through a spring tab mechanism which controls a spring tab hinged to the trailing edge of the right-hand elevator to provide aerodynamic assistance. A trim tab on the left-hand elevator is operated by hand from the flight compartment. It is also interconnected with the wing flap actuator mechanism to provide automatic elevator trim with changes in flap deflection. The elevators are internally mass-balanced and aerodynamically horn balanced. The rudder is in two sections: a hydraulically-actuated forward section and a trailing section which is geometrically linked to structure to provide double the angular movement of the forward segment relative to the airplane centerline. A combined feel and trim unit provides the rudder with artificial "feel" and by electrical operation from the flight compartment imposes bias upon the rudder as a means of trim.

4.0 FLIGHT LIMITATIONS

The following flight limitations were observed throughout the evaluation:

a. Weight Limitations

(1) Maximum takeoff gross weight	38,000 lb
(2) Maximum landing gross weight	36,500 lb
(3) Maximum zero fuel weight	34,000 lb

b. Center-of-Gravity Limitations

(1) Forward C.G. limit (gear down)	26.5 % MAC
(2) Aft C.G. limit (gear down)	41.5 % MAC

c. Airspeed Limitations

(1) Maximum Operating Airspeed	Sea Level	30 KCAS
	10,000 ft	206 KCAS
	20,000 ft	183 KCAS
(2) Maneuvering Airspeed		140 KCAS
(3) Landing Gear Extension Retraction Airspeed		140 KCAS
(4) Maximum Airspeed with Landing gear extended		160 KCAS
(5) Flaps - extended airspeed	Flaps 0	124 KCAS
	Flaps 7°	120 KCAS
	Flaps 17°	115 KCAS
	Flaps 30°	105 KCAS
	Flaps 40°	100 KCAS

d. Flight Load Acceleration Limits

(1) Flaps retracted at 38,000 lb	2.5 "g"
(2) Flaps retracted at 34,000 lb	3.0 "g"
(3) Flaps extended at 36,500 lb	2.0 "g"

e. Maximum Operating Altitude

Maximum operating altitude	25,000 ft
----------------------------	-----------

f. Engine Operating Limitations

(1) Gas generator RPM	104% (17,800 rpm) - max cont
(2) Propeller RPM	1160 rpm - max cont
(3) Turbine Inlet Temperature	630°C - max steady state for 5 min
	612°C - max steady state for 30 min
	588°C - max cont
(4) Torque	1000 ft-lb - max cont

5.0 WEIGHT AND BALANCE

The test airplane was weighed and balanced in a closed hangar after the instrumentation was installed. Weight and C.G. location were controlled for specific tests by means of lead bags placed in appropriate locations in the main cabin. No attempt was made to weigh the airplane in an uninstrumented condition inasmuch as this airplane had numerous integral instrumentation wiring and tubing that would make weighing meaningless.

The empty weight for the performance calculations was obtained from that obtained during the service test (Reference k).

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D		
(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)		
1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Aviation Test Activity (USAAVNTA) Edwards Air Force Base, California		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED
		2b. GROUP
3. REPORT TITLE Final Report of Stability and Control and Performance Test (Phase D) of the CV-7A Transport Airplane		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final Report, 19 August 1965 to 24 November 1965		
5. AUTHOR(S) (Last name, first name, initial) Blaha, John T., Project Engineer, and Mattmuller, Norman A., Major, TC, and Wilson, Donald R., Project Pilots		
6. REPORT DATE March 1966	7a. TOTAL NO. OF PAGES 134	7b. NO. OF REFS 15
8a. CONTRACT OR GRANT NO. N/A	9a. ORIGINATOR'S REPORT NUMBER(S) N/A	
b. PROJECT NO. RDT&E Project No. 1X41815D193		
c. USATECOM Project No. 4-3-1170-08	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
d. USAAVNTA Project No. 65-10	N/A	
10. AVAILABILITY/LIMITATION NOTICES U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through Hq, U. S. Army Materiel Command, CV-7A Project Manager's Office, Washington, D. C.		
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Hq, U. S. Army Materiel Command (CV-7A Project Manager)	
13. ABSTRACT An engineering flight evaluation of the CV-7A (Buffalo) Transport Airplane, S/N 63-13687, was conducted by USAAVNTA. The objective was to conduct those engineering tests required to complete the necessary engineering flight test program for an Army transport airplane. The STOL characteristics were emphasized during this evaluation. Sixty-five productive hours were flown between 19 Aug 65 and 24 Nov 65, at Edwards Air Force Base, California, and remote test sites at Lake Tahoe, California, and Leadville, Colorado. The CV-7A met all the essential performance requirements of the OMR and performance guarantees of the Model Specification that could be evaluated as a result of the limited performance tests conducted. The CV-7A presented a considerable performance improvement over the CV-2B in terms of payload while maintaining a similar STOL capability. The stability and control characteristics of the CV-7A were considerably improved over those of the CV-2B although the STOL landing handling qualities were marginal. These should be improved to take full advantage of the performance capabilities of the airplane. STOL takeoff distances were found to be shorter and STOL landing distances were slightly longer than those presented in the Operator's Manual. A considerable increase in STOL takeoff performance was achieved by loading the airplane to an aft center of gravity. Correction of two shortcomings revealed in this evaluation would result in a STOL airplane of improved capability.		

DD FORM 1473

1 JAN 64

UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Engineering Flight Evaluation CV-7A (Buffalo) Transport Airplane Army Transport Airplane Stability and Control Test Performance Test Phase D Test STOL Characteristics						

INSTRUCTIONS

1. **ORIGINATING ACTIVITY:** Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (*corporate author*) issuing the report.

2a. **REPORT SECURITY CLASSIFICATION:** Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. **GROUP:** Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. **REPORT TITLE:** Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. **DESCRIPTIVE NOTES:** If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. **AUTHOR(S):** Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. **REPORT DATE:** Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. **TOTAL NUMBER OF PAGES:** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. **NUMBER OF REFERENCES:** Enter the total number of references cited in the report.

8a. **CONTRACT OR GRANT NUMBER:** If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. **PROJECT NUMBER:** Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. **ORIGINATOR'S REPORT NUMBER(S):** Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. **OTHER REPORT NUMBER(S):** If the report has been assigned any other report numbers (*either by the originator or by the sponsor*), also enter this number(s).

10. **AVAILABILITY/LIMITATION NOTICES:** Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

- (1) "Qualified requesters may obtain copies of this report from DDC."
- (2) "Foreign announcement and dissemination of this report by DDC is not authorized."
- (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."
- (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."
- (5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. **SUPPLEMENTARY NOTES:** Use for additional explanatory notes.

12. **SPONSORING MILITARY ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring (*paying for*) the research and development. Include address.

13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.